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N77-27175

Unclas 36736

INITIAL TEST RESULTS USING THE GEOS-3 ENGINEERING MODEL ALTIMETER

G. S. Hayne
J. B. Clary

FINAL REPORT

Prepared Under Contract No. NAS6-2520 by

Applied Science Associates, Inc.
105 East Chatham Street
Apex, North Carolina 27502

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NASA CR-141421 Initial Test Results Using the GEOS-3 Engineering Model Altimeter.

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James C. Floyd
Head, Administrative Management Branch

Enclosures

N7727175

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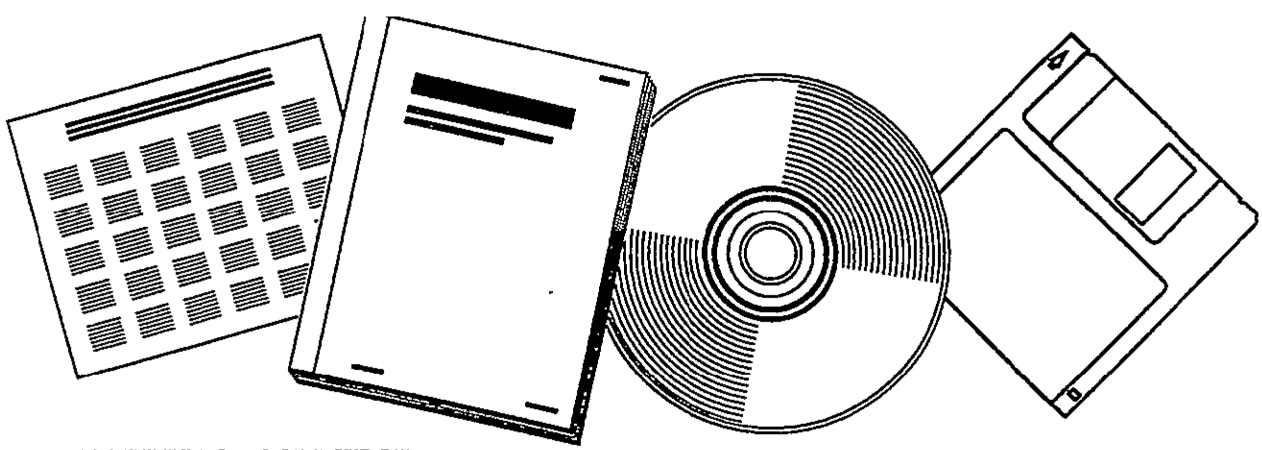
INITIAL TEST RESULTS USING THE GEOS-3 ENGINEERING MODEL ALTIMETER

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
WALLOPS ISLAND, VA

JUN 77



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15. Supplementary Notes

Report contains data from experimental tests run in a laboratory at Wallops Flight Center, with relatively little analysis or interpolation of results.

16. Abstract

This report contains data from a series of experimental tests run at NASA/Wallops Flight Center, on the Engineering Model of the GEOS-3 Radar Altimeter using the Test and Measurement System (TAMS) designed for pre-flight testing of the radar altimeter. These tests were conducted as a means of preparing and checking out a detailed test procedure to be used in running similar tests on the GEOS-3 Protoflight Model Altimeter system. The test procedures resulting from this are contained herein and are referred to as "Protoflight Model Extended Test Procedures." This sequence of events was initiated in an effort to conduct tests which, for good reason, had not previously been conducted on any of the altimeter units, but which would yield information helpful in diagnosing performance characteristics of the altimeter in flight. A later report will contain test data from the Protoflight Unit and will present more analysis and interpretation of this data.

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TABLE OF CONTENTS

1.0 INTRODUCTION

Work accomplished under this portion of Contract No. NAS6-2520 comprises experimental tests conducted using the Test and Measurement System (TAMS) and the Engineering Model of the GEOS-III radar altimeter.

This report contains sections on the experimental data obtained during the TAMS/Engineering Model tests, however, relatively little interpretation or analysis of this data has been included. The report which will be produced following the completion of similar tests now being conducted on the Protoflight Model altimeter system will cover interpretation and analysis of the overall testing activity.

One of the principal reasons for conducting the Engineering Model measurements was to enable the preparation and checkout of detailed test procedures to be used in Protoflight Unit testing. Since the Protoflight unit is still considered to be potential flight hardware, it must be protected from possible damage and the time spent in pre-flight operation of it must be minimized. It was expected that the Protoflight Model testing would be an iterative process with proposed test procedures being checked on the Engineering Model first before being carried out on the Protoflight Model. At the completion of the first round of Protoflight Model tests, additional tests would be proposed and the Engineering Model - Protoflight Model cycle would be repeated. The first such set of Protoflight Model Extended Test Procedures, as checked out on the Engineering Model, is presented as Appendix A of this report.

2.0 SUMMARY OF RESULTS

In addition to serving as a means for test checkout and evaluation, the Engineering Model Altimeter (EMA) experiments have yielded the following results:

(1) The EMA I-Mode nominal tracker bandwidth is about 1 Hz; hence, it is not representative of the Flight Model.

(2) The I-Mode break lock occurs at about -75 dBm (received power) which agrees with Flight Model experience but disagrees with earlier test results.

(3) The non-standard short pulse clutter waveforms used in the EMA

tests did not result in the low values of altitude noise recorded by the Flight Model while over ice. Observed saturation effects show that the EMA system behaves in a highly nonlinear fashion for short pulse mean waveforms. Hence, if ice backscatter data is to be properly simulated, extreme care must be taken in replicating the satellite-observed waveforms.

(4) Histograms of the altitude data showed somewhat greater skewness than previously observed.

(5) For the EMA, the AGC loop bandwidth is a function of received power level; a 3:1 bandwidth change results when the received signal is varied from -60 to -78 dBm.

(6) The waveform samplers were tested using a nonfluctuating signal having a trapezoidal shape; some differences were noted between these results and prior measurements.

3.0 ENGINEERING MODEL ALTIMETER TRACKING LOOP TESTS

3.1 Test Objectives

The objectives of the altimeter tracking loop tests are 1) to determine the response of the altitude tracker over a range of receive power levels with emphasis on low power inputs and 2) to experimentally determine the tracking loop response under simulated specular-like backscatter conditions. Both Global and Intensive Mode performance are of interest under these conditions.

3.2 Test Set-up

The TAMS/Altimeter system is well documented, [5], [6]. For ease of reference a block diagram depicting the radar altimeter and the TAMS configuration used for the tracking loop tests is shown in Figure 3.1. In the TAMS/Altimeter test set-up the Nova computer serves as a data collection and preliminary processing device. The Saicor Correlation and probability Analyzer (CAPA) is used to compute probability density and autocorrelation functions which are displayed on the plotter shown.

3.2.1 Standard Test Waveforms

To determine the altimeter response to various receive power levels a

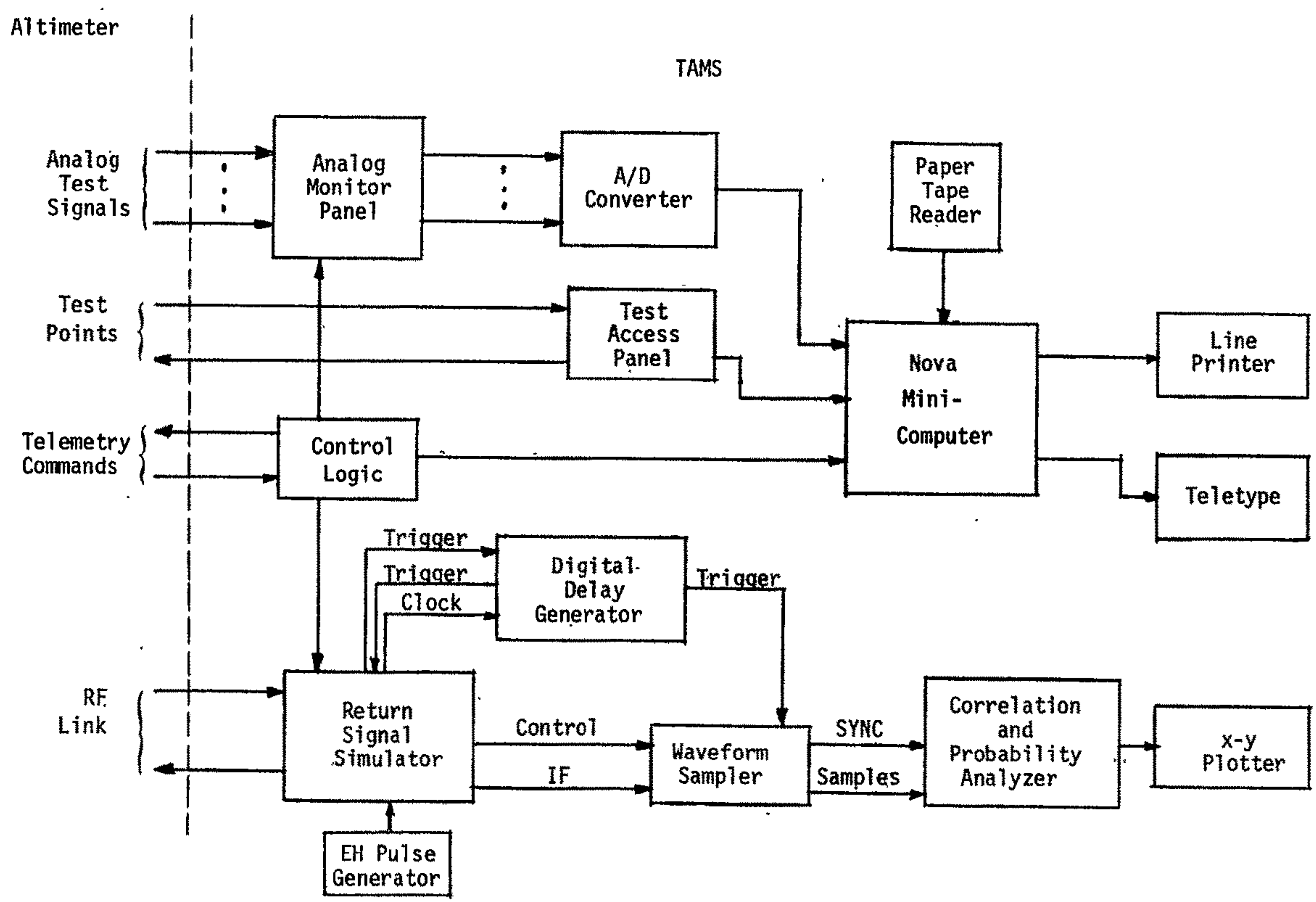


Figure 3.1. Test and Monitor System (TAMS) Functional Block Diagram.

series of tests were conducted. Both to verify the EMA performance and as a starting point for these tests, a standard input waveform used by GE for performance acceptance tests was chosen. This was done for the Global and the Intensive modes. Standard test set-up procedures are described in detail in the GEOS-III Radar Altimeter Electrical Performance Test Procedure [5]. Details of the test set-ups will not be repeated in the following discussion except where changes or modifications to the standard procedures have been made.

In the Global Mode the standard waveform used is the Group B Noise Triangular signal. In the Intensive Mode the standard waveform used is the Group C Noisy Rectangular signal (Waveheight 0). Throughout this discussion all test waveforms shown are referenced to the output of the EH test generator (see Figure 3.1).

3.2.2 Non-standard Waveforms

3.2.2.1 General

To determine the altitude tracker response to simulated over-ice and for certain terrain backscatter conditions, a set of "near-specular" waveforms were postulated and approximated using the EH pulse generator. The initial bases for these waveforms were G-Mode and I-Mode transmit pulse video waveforms found in the GEOS-III Design Error Analysis [6]. Additional bases are the theoretical waveshapes predicted in recent work by Brown [7] and Miller [8] and on-orbit data analyzed by McGoogan [10].

Before discussing the specific simulated near-specular waveforms used, two points should be made. First it is emphasized that these waveforms represent only the starting point on a learning curve. That is, test waveform information compiled from these Engineering Model tests will be modified and refined to arrive at the test waveforms and procedures for the Protoflight altimeter tests. This is true in regard to the waveform amplitude as well as the rise, fall and duration times. Second, it should be remembered that since these are non-standard waveforms (i.e. waveforms which the TAMS was not originally designed to generate) there are some basic equipment limitations which prohibit easy selection of just any waveform. For example the rise and fall times attainable using the EH pulse generator

shown in Figure 3.1 are not independently variable for all pulse widths. These considerations not withstanding, it is believed that the results obtained using this class of simulated return waveforms are helpful in characterizing the altimeter response under anomalous backscatter conditions.

3.2.2.2 Global Mode Near-Specular Waveforms

Figure 3.2 depicts the G-Mode system point target response and a photographic exposure of the response to several clutter waveforms. For comparison purposes, Figure 3.3 shows the G-Mode point target response as recorded during the acceptance test period.

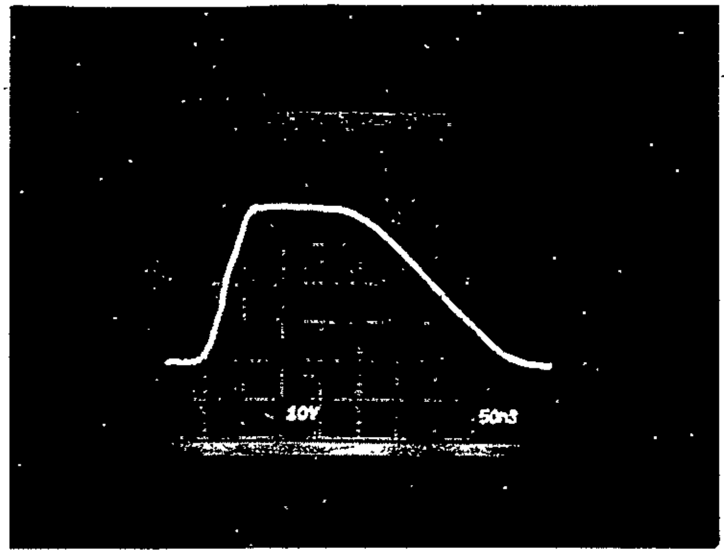
Figures 3.4 through 3.6 show the rest of the family of near-specular G-Mode waveforms used in these initial tests. A constant rise time of 100 ns and a pulse width (at maximum amplitude) of 150 ns was held while the fall time was varied from 350 ns to 750 ns for the waveforms shown in Figure 3.4. For the waveforms of Figure 3.5 a constant rise time of 50 ns and a fall time of 200 ns was maintained while the pulse widths (again at maximum amplitude) were varied from 200 ns to 300 ns. Finally, Figure 3.6 shows two waveforms with 25 ns rise times and 300 ns fall times with widths (at maximum amplitude) of 375 ns and 475 ns.

The Engineering Model Global Mode tracking loop response to these waveforms is discussed in Section 3.3.2.

3.2.2.3 Intensive Mode Near-Specular Waveforms

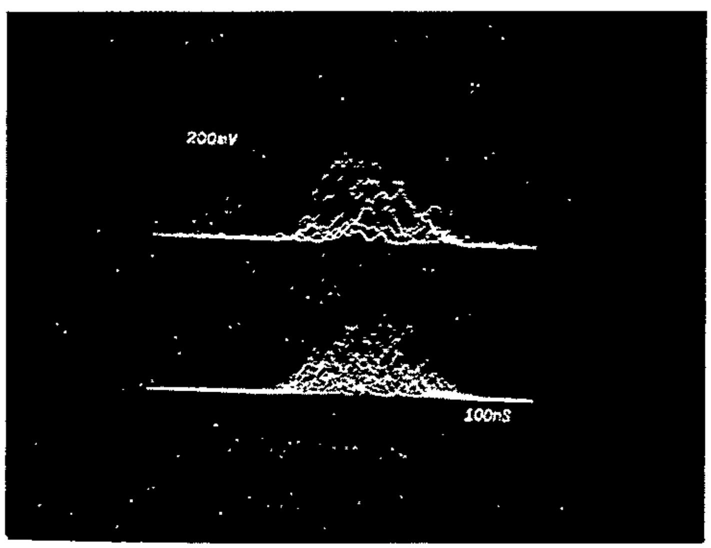
In I-Mode the half power width of the Gaussian shaped point target response is approximately 14 ns while the I-Mode ramp and plateau gates are spaced 50 ns apart. This means that as the return waveform pulse width approaches the point target response width, the split gate tracking law is more difficult to satisfy. As a consequence and in particular for the Engineering Model altimeter the minimum simulated return pulse width which could be consistently tracked is on the order of 40 ns for 5 ns rise and fall times.

Figure 3.7 depicts the initial approximation to the I-Mode point target response. This waveform is but a gross approximation to the measured I-Mode point target response, the limitation being the minimum track lock



Vertical - 1 v/div.   Horizontal - 50 ns/div.

a. Waveform G-1



Vertical - 200 mv/div.   Horizontal - 100 ns/div.

b. Altimeter Video Output. G-Mode Waveform G-1. Pr = -73 dBm.

Figure 3.2. G-Mode Point Target Response Waveform and typical G-1 waveforms.

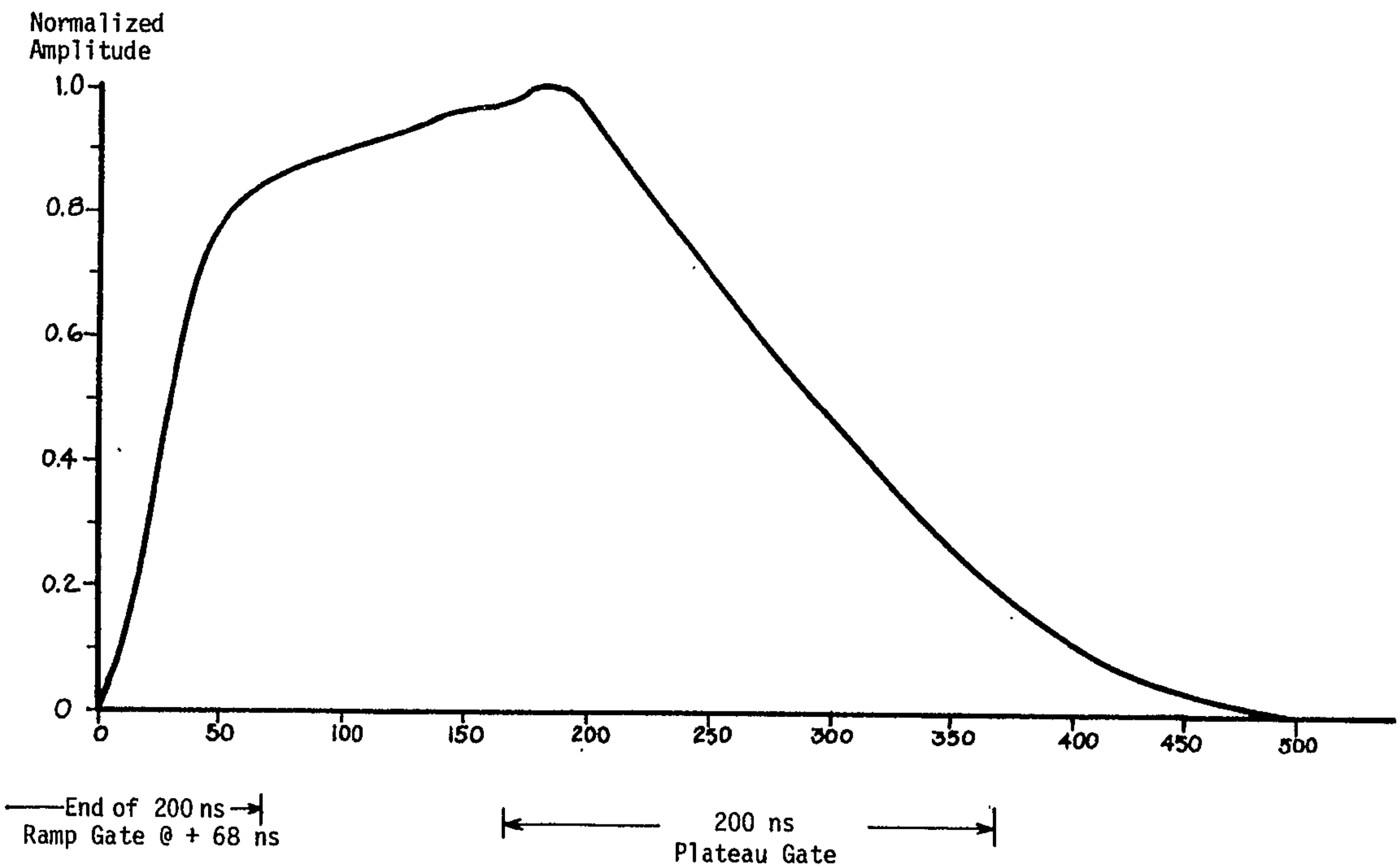
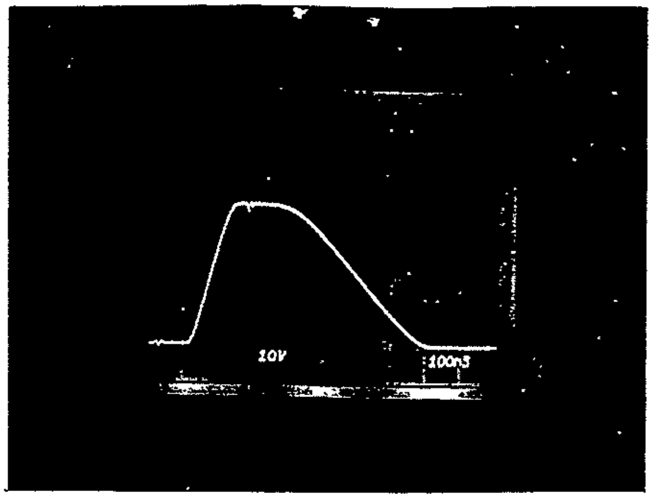
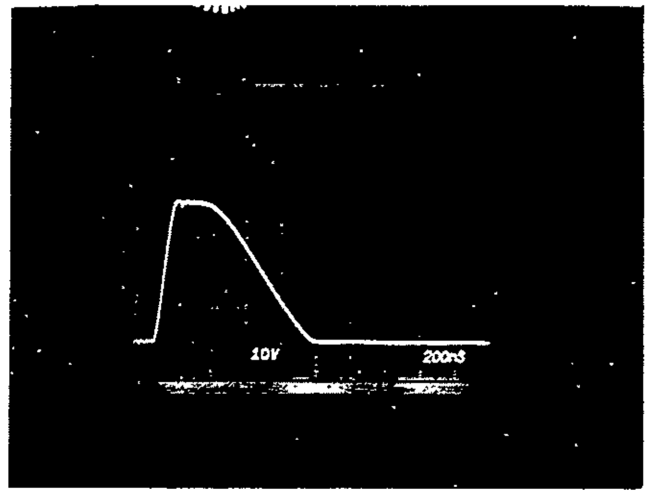


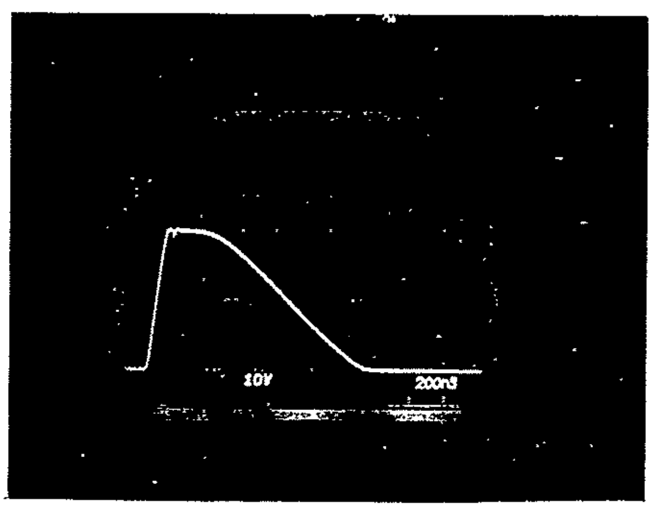
Figure 3.3. G-Mode Transmit Pulse Video Waveform Seen at G-Mode Split Gate Tracker (Flight Altimeter), from [6].



Vertical - 1 v/div. Horizontal - 100 ns/div.
a. Waveform G-2

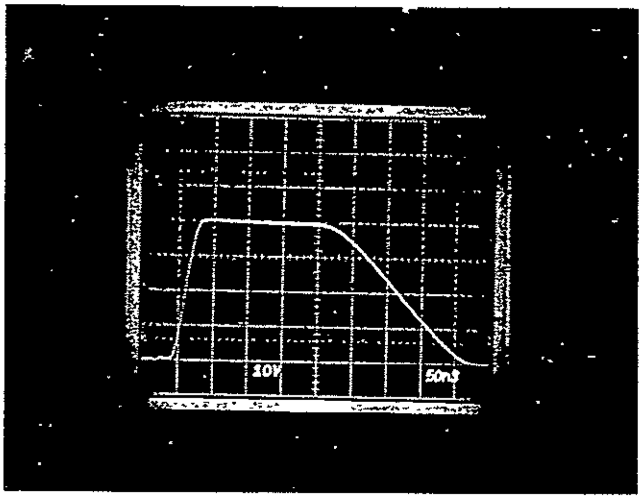


Vertical - 1 v/div. Horizontal - 200 ns/div.
b. Waveform G-3

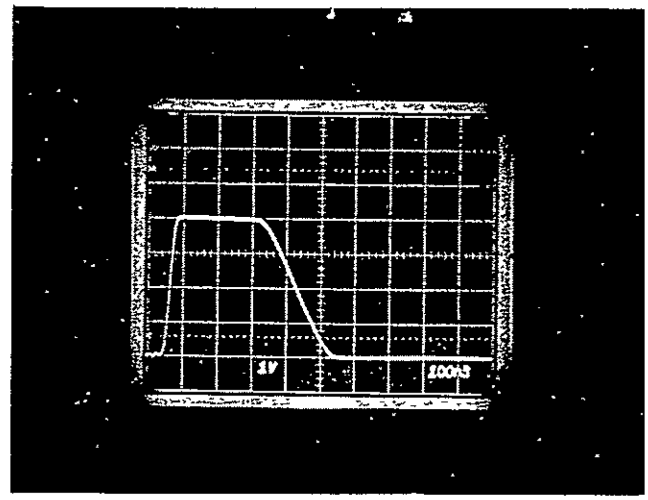


Vertical - 1 v/div. Horizontal - 200 ns/div.
c. Waveform G-4

Figure 3.4. G-Mode Non-Standard Test Waveforms - 100 ns Rise Time



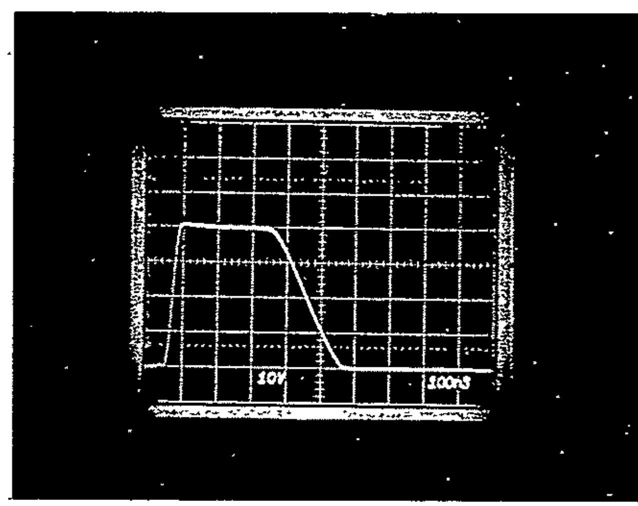
Vertical - 1 v/div. Horizontal - 50 ns/div.
Waveform G-6



Vertical - 1 v/div. Horizontal - 100 ns/div.
Waveform G-7

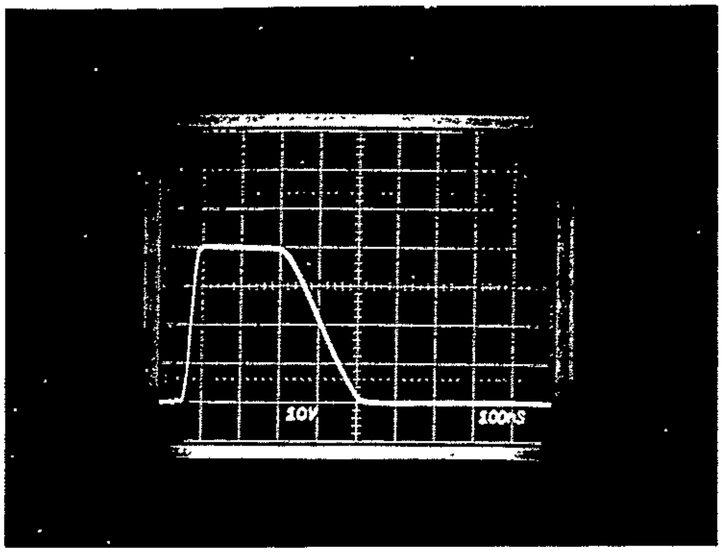
Same As
G-7 Except
τ = 362 ns.

Waveform G-8

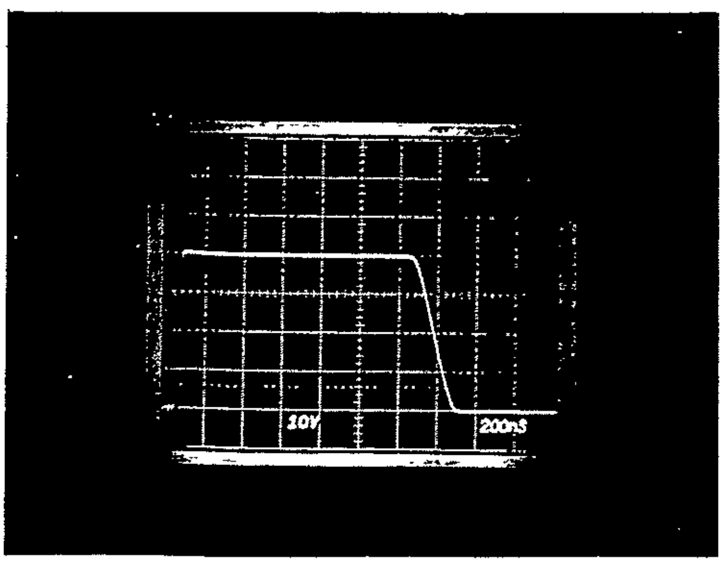


Vertical - 1 v/div. Horizontal - 100 ns/div.
Waveform G-9

Figure 3.5a. G-Mode Test Waveforms - 50 ns Rise Time

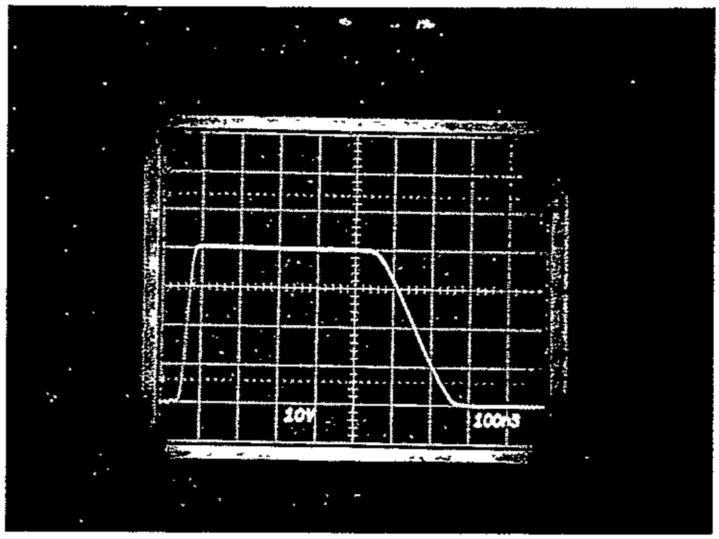


Vertical - 1 v/div. Horizontal - 100 ns/div.
Waveform G-10

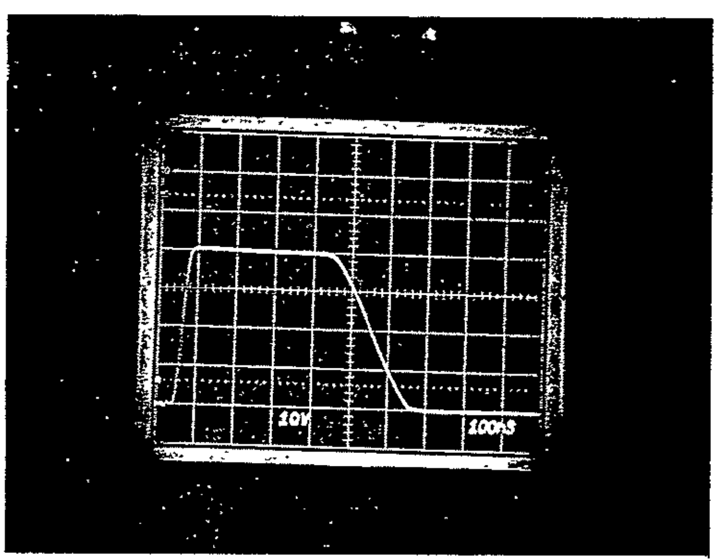


Vertical - 1 v/div. Horizontal - 200 ns/div.
Waveform G-11

Figure 3.5b. G-Mode Test Waveforms - 50 ns Rise Time



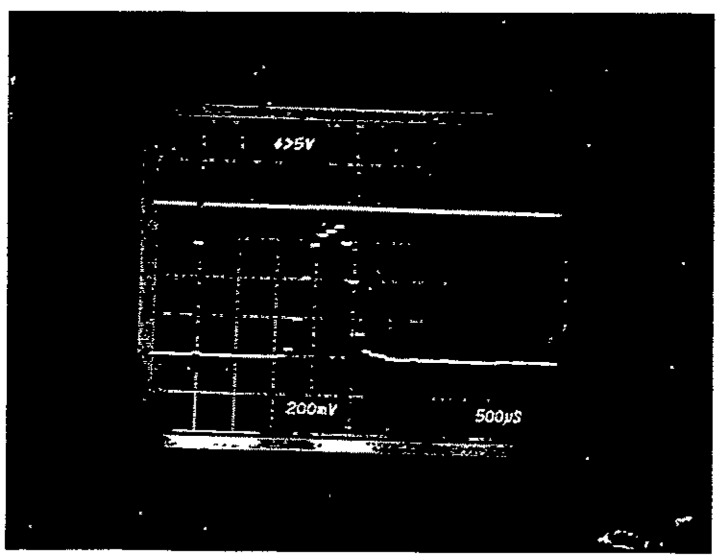
Vertical - 1 v/div. Horizontal - 100 ns/div.
a. Waveform G-12



Vertical - 1 v/div. Horizontal - 100 ns/div.
b. Waveform G-13

Figure 3.6. G-Mode Test Waveforms - 25 ns Rise Time

Vertical - 1 v/div.   Horizontal - 10 ns/div.
a. Waveform I-1



b. Post detection shape of the waveform shown in a. (CAPA averaged, 6.25 ns quantization).

Figure 3.7. I-Mode Minimum Width Waveform (I-1).

pulse width as discussed above. The I-Mode post-detection point target response is shown in Figure 3.8 from reference [6].

Figure 3.9 depicts the remaining members of the family of near-specular waveforms used in the initial Engineering Model altimeter tests. A constant rise and fall time of 5 ns is maintained while the pulse width is varied from 50 ns to 140 ns.

The EMA tracking loop response to these waveforms is discussed in Section 3.3.3 for the Intensive mode.

3.3 Test Results

3.3.1 General

The data in this section are from two levels of processing. First a tabular summary of the results obtained using the test set-up described above is presented. These data were compiled from the TAMS computer printouts and are indexed by waveshape and received signal amplitude. The second group of data results from additional processing of the first group. Also included in this category are data processed by the Saicor probability and correlation analyzer.

In some cases tabular data have not been converted from engineering units to functional units. This was done in the interest of conserving time spent on the Engineering Model altimeter test results, particularly in cases where it was felt that the Protoflight model results might supersede those obtained using the Engineering Model. In other cases it was felt that the engineering unit numbers serve as useful "trend" indicators.

A summary of the G-Mode computer tabular data is given in Tables 3.1 through 3.3. The indicated pulse designations in these tables refer to those waveforms depicted in Figures 3.2 through 3.6 (except 3.3). In addition results with the standard Group B Noisy Triangular waveform are shown. The altimeter receive power was obtained using the standard calibration procedure for each waveform as described in Reference [5]. The standard deviations in the Global Mode summary table result from computing the standard deviation of one second of altimeter data.

A summary of the I-Mode computer tabular data is presented in Tables 3.4 through 3.6. The indicated pulse designations in these tables refer to

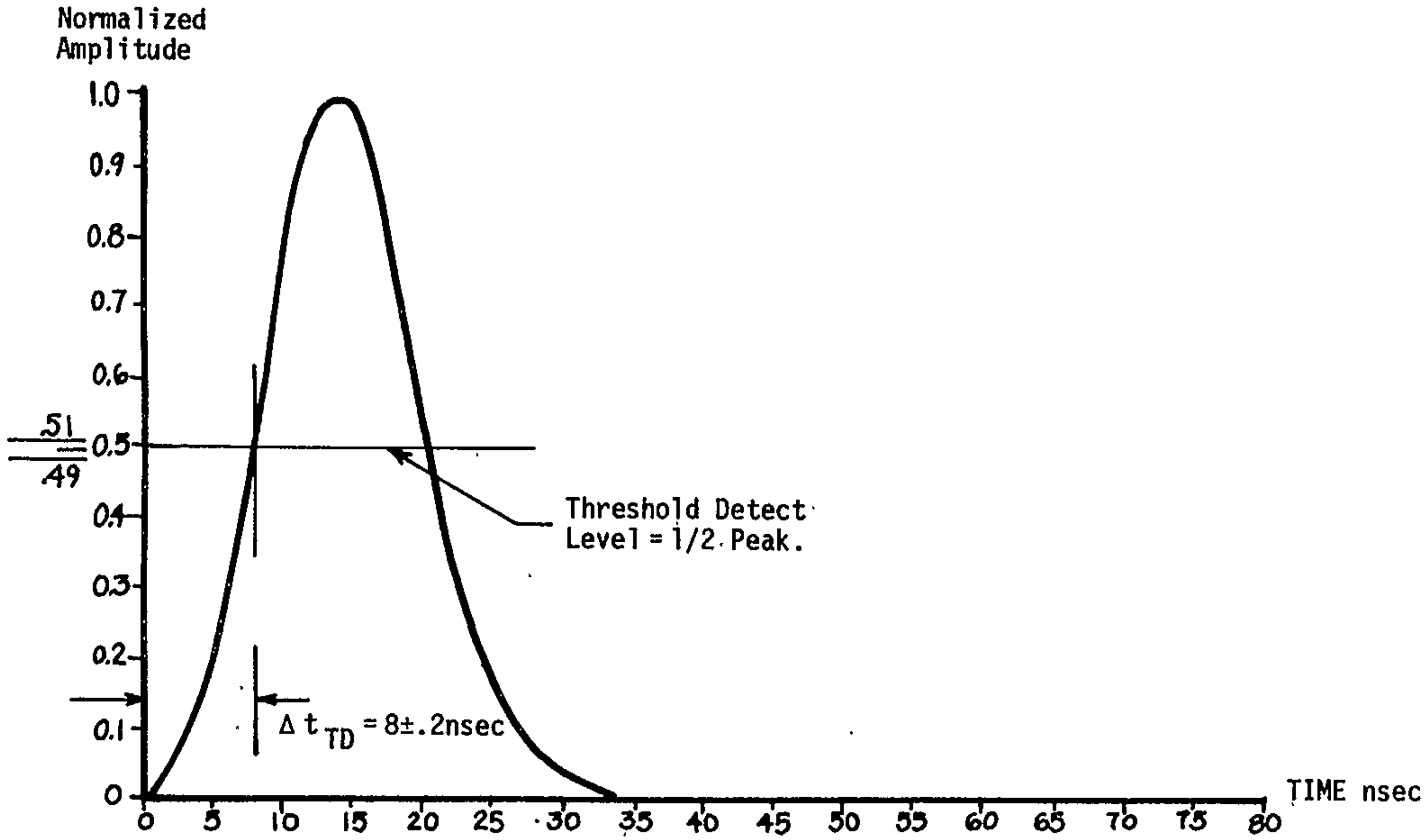
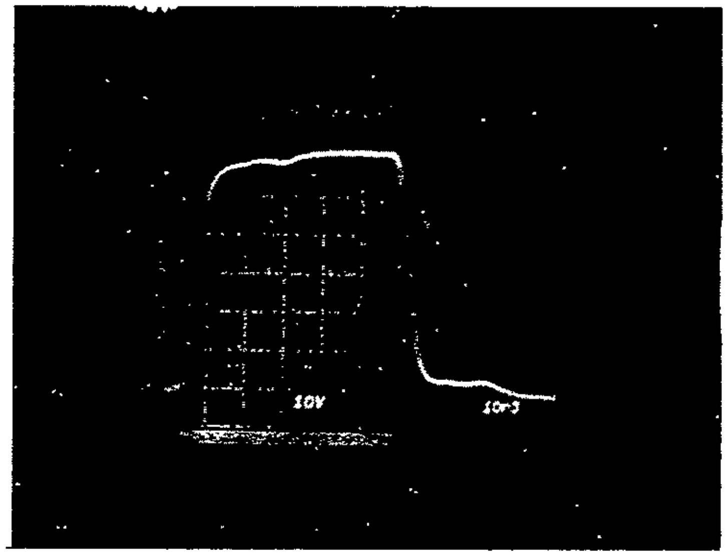
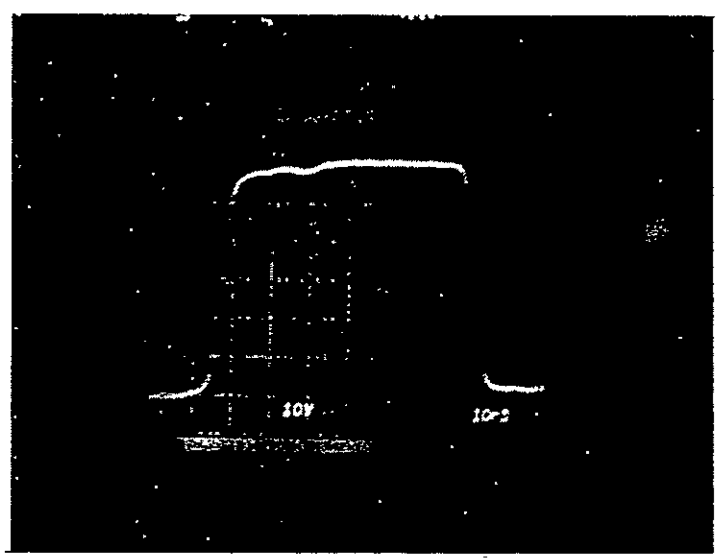


Figure 3.8. I-Mode Square Law Detected Compressed Pulse Video Waveform, from [6].



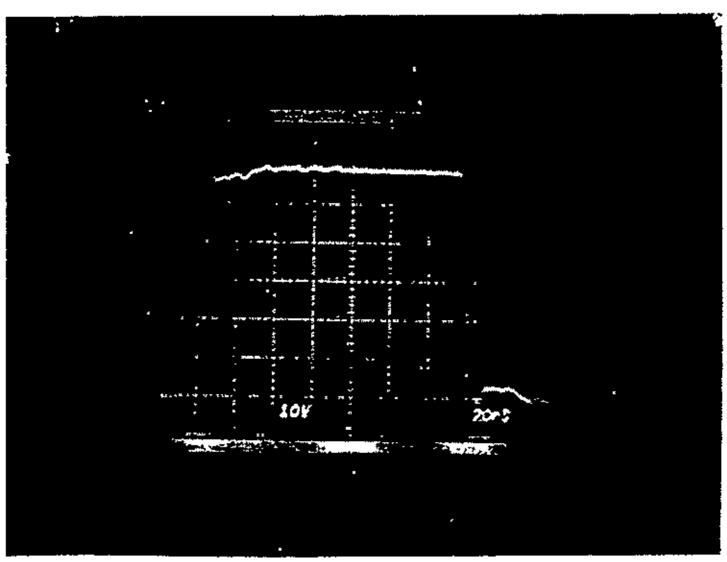
Vertical - 1 v/div. Horizontal - 10 ns/div.
Waveform I-2



Vertical - 1 v/div. Horizontal - 10 ns/div.
Waveform I-3

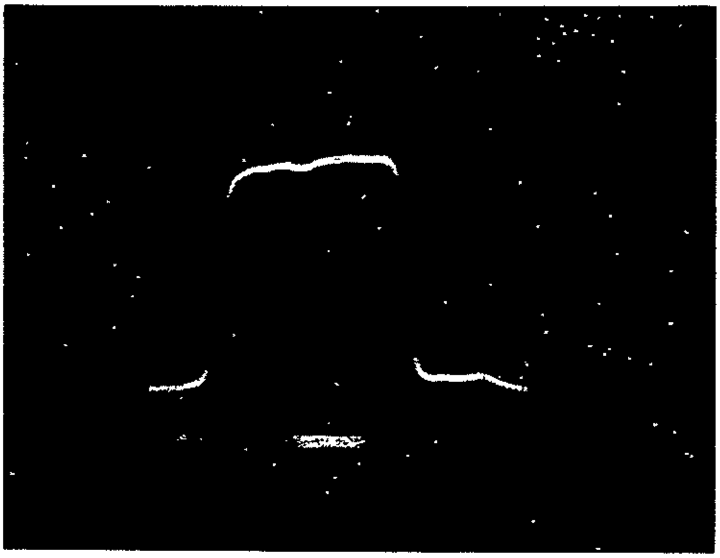
Figure 3.9a. I-Mode Test Waveforms - 5 ns Rise Time

Vertical - 1 v/div.   Horizontal - 10 ns/div.
Waveform I-4

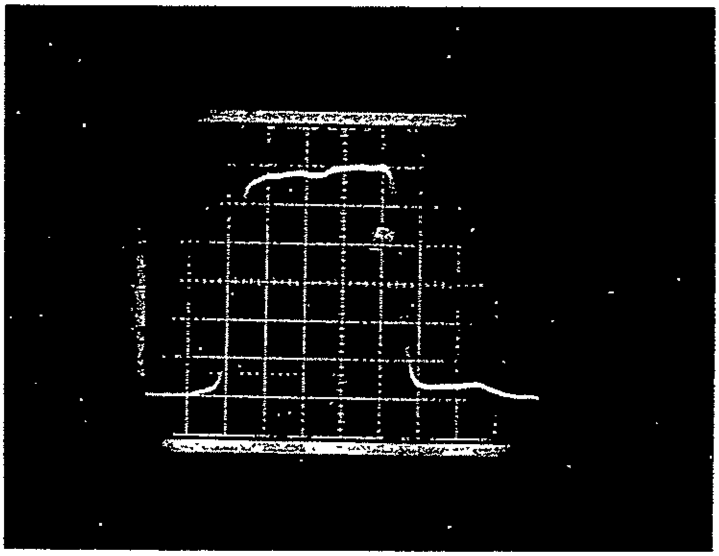


Vertical - 1 v/div.   Horizontal - 20 ns/div.
Waveform I-5

Figure 3.9b. I-Mode Test Waveforms - 5 ns Rise Time



Vertical - 1 v/div.   Horizontal - 10 ns/div.
Waveform I-6



Vertical - 1 v/div.   Horizontal - 10 ns/div.
Waveform I-7

Figure 3.9c. I-Mode Test Waveforms - 5 ns Rise Time

TAMS EXTENDED TEST DATA SUMMARY

Date: 12/2-3/75 Mode: Global ET -

EPTP REFERENCE: ¶ 6.4.1

TAMS # 2 RSS # 1 Altimeter Engineering Model

Exceptions: 1) RF/IF/Statistics Level Adjust= 16 dB

CCV + WGL (from EPTP 4.8 and 4.10) 39.8 dB

2) Measured RFCPPL = Variable dBm

3) Pulse Shape - Variable

Date	Time	RSS Input Pulse	RSS RF Output Attn (dB)	Altimeter Rcvd Pwr (dBm)	Altitude Delay (ns)	Tracking Jitter (ns)	Time Disc (volts) MUX 6	AGC Control (volts) MUX 8	V(N) (volts) MUX 9	V(A/S) (volts) MUX 10	V(R) (volts) MUX 11	V(P) (volts) MUX 12	V(P_t) (volts) MUX 15	V(AGC)-volts Mean MUX 16	V(AGC)-volts Std Dev
12-2-75	1825	Group B Noisy Triangular	0	-64.9	5620899.47	6.15	-0.006	+4.291	+0.000	1.726	0.461	0.932	0.521	+1.062	0.0123
	2310		4	-68.9	5620899.05	6.22	-0.002	+4.206	+0.001	1.732	0.456	0.924	0.510	+0.709	0.0109
	2220		8	-72.9	5620898.99	6.19	-0.015	+4.102	+0.000	1.694	0.450	0.911	0.506	+0.291	0.0122
	2330		12	-76.9	5620899.56	6.33	-0.007	+3.986	-0.001	1.678	0.443	0.897	0.509	-0.170	0.0122
	2200		16	-80.9	5620899.53	6.38	-0.012	+3.883	-0.010	1.633	0.437	0.886	0.502	-0.593	0.0134
	2355		20	-84.9	5620900.08	6.96	-0.007	+3.741	-0.037	1.562	0.428	0.867	0.487	-1.162	0.0146
	2130		27	-91.9	5620894.00	8.98	+0.000	+3.387	-0.065	1.364	0.406	0.826	0.416	-2.587	0.0476
12-3-75	1215	G-1 (τ=275 ns)	0	-65.0	5620863.80	3.42	-0.002	+4.250	+0.001	-0.030	0.456	0.928	0.515	+0.892	0.0171
	1150		8	-73.0	5620863.77	3.31	+0.001	+4.039	+0.000	-0.036	0.443	0.903	0.483	+0.041	0.0159
	1015		16	-81.0	5620863.47	3.60	-0.001	+3.830	-0.015	-0.058	0.430	0.878	0.489	-0.803	0.0232
	1115		24	-89.0	5620863.72	3.83	-0.003	+3.459	-0.131	-0.139	0.408	0.833	0.433	-2.293	0.0390
12-3-75	1400	G-2 (τ=400 ns)	0	-65.0	5620962.11	6.73	-0.010	+4.278	+0.003	+0.078	0.457	0.932	0.516	+1.008	0.0122
	1515		8	-73.0	5620962.95	6.80	-0.003	+4.067	+0.001	+0.074	0.445	0.905	0.495	+0.155	0.0110
	1420		16	-81.0	5620963.62	7.11	-0.013	+3.845	-0.010	+0.054	0.432	0.880	0.471	-0.734	0.0134
	1450		24	-89.0	5620963.83	8.36	+0.000	+3.535	-0.093	-0.030	0.413	0.842	0.434	-1.982	0.0268

Notes: 1. See text and figures for complete pulse description.

Table 3.1

TAMS EXTENDED TEST DATA SUMMARY

Date: 12/3/75 Mode: Global ET - EPTP REFERENCE: ¶ 6.4.1

TAMS # 2 RSS # 1 Altimeter Engineering Model

CCV + WGL (from EPTP 4.8 and 4.10) 39.8 dB

Exceptions:
1) RF/IF/Statistics Level Adjust= 16 dB
2) Measured RFCPPL = Variable dBm
3) Pulse Shape - Variable

Date	Time	RSS Input Pulse	RSS RF Output Attn(dB)	Altimeter Rcvd Pwr (dBm)	Altitude Delay (ns)	Tracking Jitter (ns)	Time Disc (volts) MUX 6	AGC Control (volts) MUX 8	V(N) (volts) MUX 9	V(A/S) (volts) MUX 10	V(R) (volts) MUX 11	V(P) (volts) MUX 12	$V(P_t)$ (volts) MUX 15	V(AGC)-volts Mean MUX 16	V(AGC)-volts Std Dev
12-3-75	1540	G-3 (τ=600 ns)	0	-65.0	5620957.53	7.03	-0.013	+4.274	+0.002	+1.320	0.458	0.931	0.515	+0.993	0.0110
↓	1610	↓	8	-73.0	5620958.51	7.30	-0.003	+4.067	+0.000	+1.260	0.446	0.905	0.495	+0.157	0.0120
	1635		16	-81.0	5620959.07	7.45	-0.003	+3.846	-0.013	+1.208	0.433	0.880	0.488	-0.728	0.0134
	1700		24	-89.0	5620958.67	8.90	-0.014	+3.540	-0.092	+1.097	0.415	0.843	0.424	-1.961	0.0281
12-3-75	1740	G-4 (τ=700 ns)	0	-65.0	5620951.70	7.65	-0.004	+4.277	+0.002	+2.001	0.460	0.931	0.499	+1.002	0.0109
12-3-75	2045	G-6[2] (τ=300 ns)	0	-65.0	5620853.65	3.79	-0.014	+4.312	+0.006	-0.036	0.461	0.937	0.539	+1.135	0.0207
12-3-75	2115	G-7 (τ=350 ns)	0	-65.0	5620876.35	6.16	-0.002	+4.324	+0.004	-0.015	0.460	0.938	0.520	+1.185	0.0171
12-3-75	2140	G-8 (τ=362 ns)	0	-65.0	5620869.84	5.04	-0.006	+4.309	+0.006	-0.024	0.458	0.936	0.520	+1.124	0.0122
12-3-75	2205	G-9 (τ=375 ns)	0	-65.0	5620873.50	5.45	-0.002	+4.309	+0.006	-0.020	0.460	0.936	0.516	+1.125	0.0134
12-3-75	2230	G-10 (τ=325 ns)	0	-65.0	5620862.86	4.62	-0.004	+4.289	+0.002	-0.031	0.458	0.933	0.517	+1.047	0.0159
↓	2300	↓	12	-77.0	5620863.46	4.95	-0.003	+3.963	-0.002	-0.037	0.439	0.894	0.495	-0.263	0.0150
	2325		24	-89.0	5620863.28	5.21	+0.002	+3.531	-0.112	-0.133	0.413	0.842	0.444	-2.001	0.0310

Notes: 1. See text and figures for complete pulse description.
2. Waveform number G-5 does not exist.

Table 3.2

TAMS EXTENDED TEST DATA SUMMARY

Date: 12/3-4/75 Mode: Global ET –

TAMS # 2 RSS # 1 Altimeter Engineering Model

CCV + WGL (from EPTP 4.8 and 4.10) 39.8 dB

EPTP REFERENCE: ¶ 6.4.1

Exceptions: 1) RF/IF/Statistics Level Adjust= 16 dB

2) Measured RFCPPL = Variable dBm

3) Pulse Shape – Variable

Date	Time	RSS Input Pulse	RSS RF Output Attn(dB)	Altimeter Rcvd Pwr (dBm)	Altitude Delay (ns)	Tracking Jitter (ns)	Time Disc (volts) MUX 6	AGC Control (volts) MUX 8	V(N) (volts) MUX 9	V(A/S) (volts) MUX 10	V(R) (volts) MUX 11	V(P) (volts) MUX 12	V(P_t) (volts) MUX 15	V(AGC)–volts Mean MUX 16	V(AGC)–volts Std Dev
12-3-75	2345	G-11 (τ=1325 ns)	0	-65.0	5620880.36	7.12	-0.006	+4.301	+0.000	+2.092	0.462	0.935	0.523	+1.096	0.0109
12-4-75	0015	G-12 (τ=600 ns)	0	-65.0	5620880.25	6.91	-0.017	+4.300	+0.015	+0.465	0.460	0.935	0.532	+1.092	0.0109
12-4-75	0045	G-13 (τ=500 ns)	0	-65.0	5620879.63	7.15	-0.002	+4.298	+0.006	+0.054	0.458	0.935	0.513	+1.085	0.0122

Notes: 1. See text and figures for complete pulse description.

Table 3.3

TAMS EXTENDED TEST DATA SUMMARY

Date: 12/4/75 Mode: Intensive ET -- EPTP REFERENCE: ¶ 6.4.2

TAMS # 2 RSS # 1 Altimeter Engineering Model

CCV + WGL (from EPTP 4.8 and 4.10) 39.8 dB

Exceptions: 1) RF/IF/Statistics Level Adjust= 16 dB

2) Measured RFCPPL = Variable dBm

3) Pulse Shape - Variable

Date	Time	RSS Input Pulse	RSS RF Output Attn(dB)	Altimeter Rcvd Pwr (dBm)	Altitude Delay (ns)	Tracking Jitter (ns)	Time Disc (volts) MUX 6	AGC Control (volts) MUX 8	V(N) (volts) MUX 9	V(A/S) (volts) MUX 10	V(R) (volts) MUX 11	V(P) (volts) MUX 12	$V(P_t)$ (volts) MUX 15	V(AGC)-volts Mean MUX 16	V(AGC)-volts Std Dev
12-4-75	0930	Waveheight 0	0	-63.6	5624177.34	2.86	-0.009	4.067	-0.014	+2.106	0.435	0.908	+0.502	+0.323	0.0790
↓	1000	↓	4	-67.6	5624177.59	4.00	-0.013	3.428	-0.029	+2.069	0.428	0.891	+0.468	-0.217	0.0866
	1010		8	-71.6	5624178.10	3.39	-0.001	3.776	-0.070	+1.989	0.417	0.872	+0.402	-0.837	0.1208
	1020		10	-73.6	5624179.04	4.70	-0.035	3.643	-0.137	+1.943	0.411	0.856	+0.461	-1.362	0.2124
12-4-75	1145	I-1 (τ=40 ns)	0	-63.6	5624168.89	4.84	-0.100	3.796	-0.102	-0.062	0.421	0.874	0.462	-0.744	0.1320
12-4-75	1515	I-2 (τ=50 ns)	0	-63.6	5624163.55	1.70	+0.040	3.879	-0.032	-0.032	0.422	0.883	0.405	-0.405	0.0634
12-4-75	1530 1630	I-3 (τ=60 ns)	0	-63.6	5624165.92	1.70	+0.012	3.983	-0.002	-0.015	0.429	0.895	0.415	+0.012	0.0525
12-4-75	1745	I-4 (τ=70 ns)	0	-63.6	5624167.90	2.02	-0.035	4.022	+0.001	-0.014	0.429	0.899	0.474	+0.172	0.047
12-4-75	2030	I-5 (τ=140 ns)	0	-63.6	5624170.86	3.12	+0.017	4.082	+0.001	-0.017	0.434	0.906	0.521	+0.397	0.024
12-4-75	2050	I-6 (τ=40 ns)	0	-63.6	5624163.52	2.02	-0.034	3.829	-0.087	-0.059	0.421	0.878	0.463	-0.617	0.0976

Note: 1. See text and figures for complete pulse description.

Table 3.4

TAMS EXTENDED TEST DATA SUMMARY

Date: 12/4/75 Mode: Intensive ET - EPTP REFERENCE: ¶ 6.4.2

TAMS # 2 RSS # 1 Altimeter Engineering Model

CCV + WGL (from EPTP 4.8 and 4.10) 39.8 dB

Exceptions: 1) RF/IF/Statistics Level Adjust= 16 dB

2) Measured RFCPPL = Variable dBm

3) Pulse Shape - Variable

Date	Time	RSS Input Pulse	RSS RF Output Attn(dB)	Altimeter Rcvd Pwr (dBm)	Altitude Delay (ns)	Tracking Jitter (ns)	Time Disc. (volts) MUX 6	AGC Control (volts) MUX 8	V(N) (volts) MUX 9	V(A/S) (volts) MUX 10	V(R) (volts) MUX 11	V(P) (volts) MUX 12	$V(P_t)$ (volts) MUX 15	V(AGC)-volts Mean MUX 16	V(AGC)-volts Std Dev
12-4-75	2105	I-7 (τ=35 ns)	0	-63.6	5624162.70	3.25	-0.057	3.720	-0.194	-0.096	0.412	0.864	0.432	-1.044	0.1892
12-4-75	2125	I-8 (Group C)	0	-63.6	5624168.91	3.16	+0.018	4.028	-0.015	+1.892	0.434	0.900	0.494	+0.181	0.083

Note: 1. See text and figures for complete pulse description.

Table 3.5

TAMS EXTENDED TEST DATA SUMMARY

Date: 12/10/75 Mode: Intensive ET - EPTP REFERENCE: ¶ 6.4.2

TAMS # 2 RSS # 1 Altimeter Engineering Model

CCV + WGL (from EPTP 4.8 and 4.10) 39.8 dB

Exceptions: 1) RF/IF/Statistics Level Adjust= ______ dB

2) Measured RFCPPL = Variable dBm

3) Pulse Shape - Variable

Date	Time	RSS Input Pulse	RSS RF Output Attn(dB)	Altimeter Rcvd Pwr (dBm)	Altitude Delay (ns)	Tracking Jitter (ns)	Time Disc (volts) MUX 6	AGC Control (volts) MUX 8	V(N) (volts) MUX 9	V(A/S) (volts) MUX 10	V(R) (volts) MUX 11	V(P) (volts) MUX 12	$V(P_t)$ (volts) MUX 15	V(AGC)-volts Mean MUX 16	Std Dev
12-10-75	1145	Waveheight 0	0	-63.5	5624155.10	2.61	+0.035	4.053	-0.009	+2.180	0.437	0.905	0.499	+0.284	0.0670
↓	1115	↓	6	-69.5	5624155.89	2.95	-0.085	3.889	-0.029	+2.075	0.429	0.885	0.482	-0.363	0.0855
	1130		10	-73.5	5624156.89	2.86	-0.001	3.721	-0.089	+2.004	0.416	0.866	0.447	-1.029	0.1379
12-10-75	1325	I-5 (τ=140 ns)	0	-63.5	5624156.46	2.06	-0.013	4.118	+0.004	-0.028	0.437	0.913	0.516	+0.531	0.0549
↓	1350	↓	6	-69.5	5624156.26	2.41	-0.039	3.939	+0.000	-0.025	0.427	0.892	0.499	-0.177	0.0570
	1410		15	-78.5	5624157.88	3.90	+0.021	3.551	-0.067	-0.052	0.405	0.845	0.463	-1.704	0.1780
12-10-75	1440	I-4 (τ=70 ns)	0	-63.5	5624157.67	2.16	-0.018	4.096	+0.006	-0.015	0.437	0.910	0.485	+0.446	0.0510
↓	1530	↓	6	-69.5	5624181.44[2]	3.03	-0.041	3.919	+0.000	-0.019	0.424	0.887	0.472	-0.247	0.0570
	1545		16	-79.5	5624182.44	4.65	+0.004	3.428	-0.058	-0.043	0.396	0.828	0.432	-2.17	0.1660
12-10-75	1650	I-1 (τ=40 ns)	0	-63.5	5624178.70	2.19	-0.058	4.056	+0.002	-0.018	0.432	0.902	0.488	+0.299	0.0500
↓	1705	↓	6	-69.5	5624179.01	2.38	-0.061	3.887	+0.000	-0.020	0.422	0.883	0.456	-0.367	0.0510
	1730		15	-78.5	5624180.10	3.40	-0.056	3.931	-0.054	-0.043	0.393	0.828	0.454	-2.169	0.2550

Notes: 1. See text and figures for complete pulse description.
2. 23 ns was added to DDG setting.

Table 3.6

those waveforms depicted in Figures 3.7 and 3.9. In addition results with the standard Group C Noisy Rectangular waveform are presented. The standard deviations in the Intensive Mode summary table result from computing the standard deviation of 10 per second altimeter data.

These data along with the Saicor processed autocorrelation functions (ACF's) and Probability Density Functions (PDF's) provide the basis for the following tracking loop test results.

3.3.2 Global Mode Results

3.3.2.1 Altitude Jitter Versus Receive Power

Figure 3.10 shows altitude jitter, σ_h, as a function of altimeter received power for three test waveforms. Because the receiver saturates with 40 to 80 ns clutter waveforms, the measured values shown here apply only to the specific waveshapes used. These curves are in general agreement with the predicted tracking error performance from [6] and repeated for convenience in Figure 3.10a.

The relationship of the 50 ns rise time waveform (G-1) response to the Group B Noisy Triangular waveform response verifies that for some specular-like waveforms, the altitude jitter may actually decrease slightly. At the same time, however, the 100 ns rise time waveform response is very nearly the same as the group B response and even indicates a slight increase in altitude jitter.

3.3.2.2 Tracking Error Distribution Versus Receive Power

Figures 3.11 through 3.13 show the altitude error probability distribution function (PDF) for the standard test waveform (Group B Noisy Triangular) for three different received power levels. To quantify the degree of the skewness apparent in these waveforms the third central moment, μ_3, was computed from

$$\mu_3 = \frac{\Sigma n(x)x^3}{N} - 3\mu_2 \zeta - \zeta^3 \qquad (3\text{-}2)$$

where

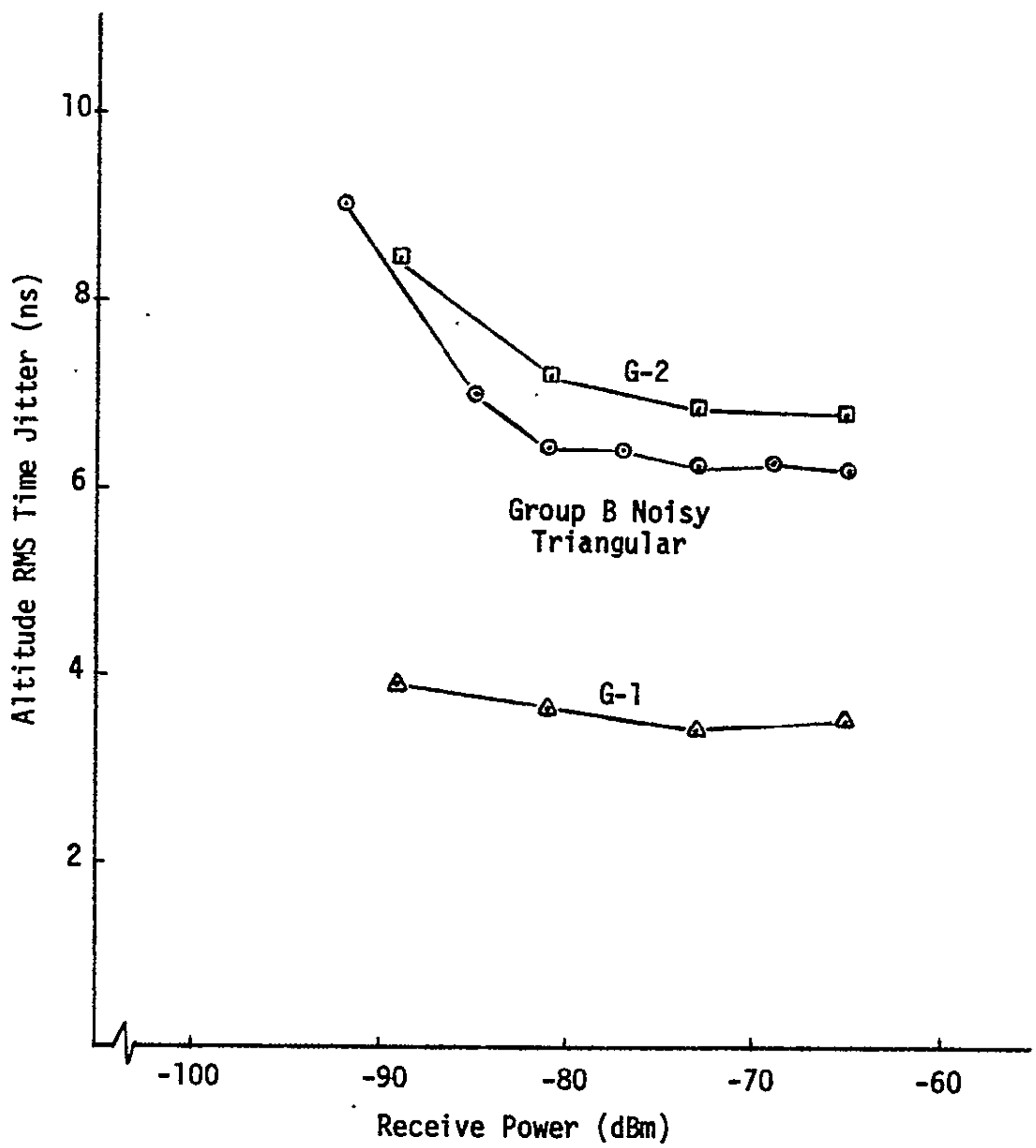


Figure 3.10. Global Mode Tracking Jitter Versus Altimeter Receive Power.

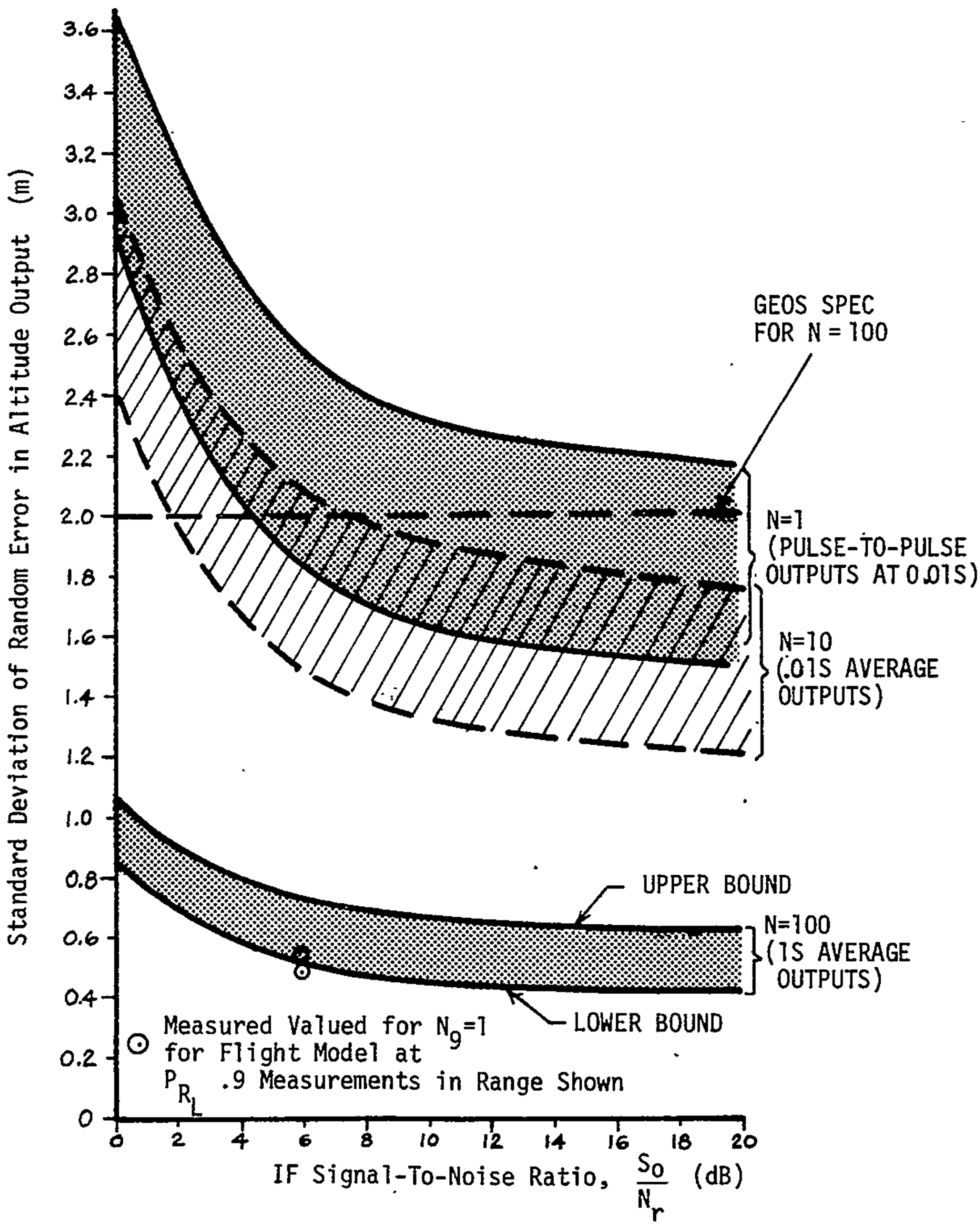


Figure 3.10a. Global Mode Height Measurement Performance versus Signal-to-Noise Ratio for Different Altitude Output Rates, from [6].

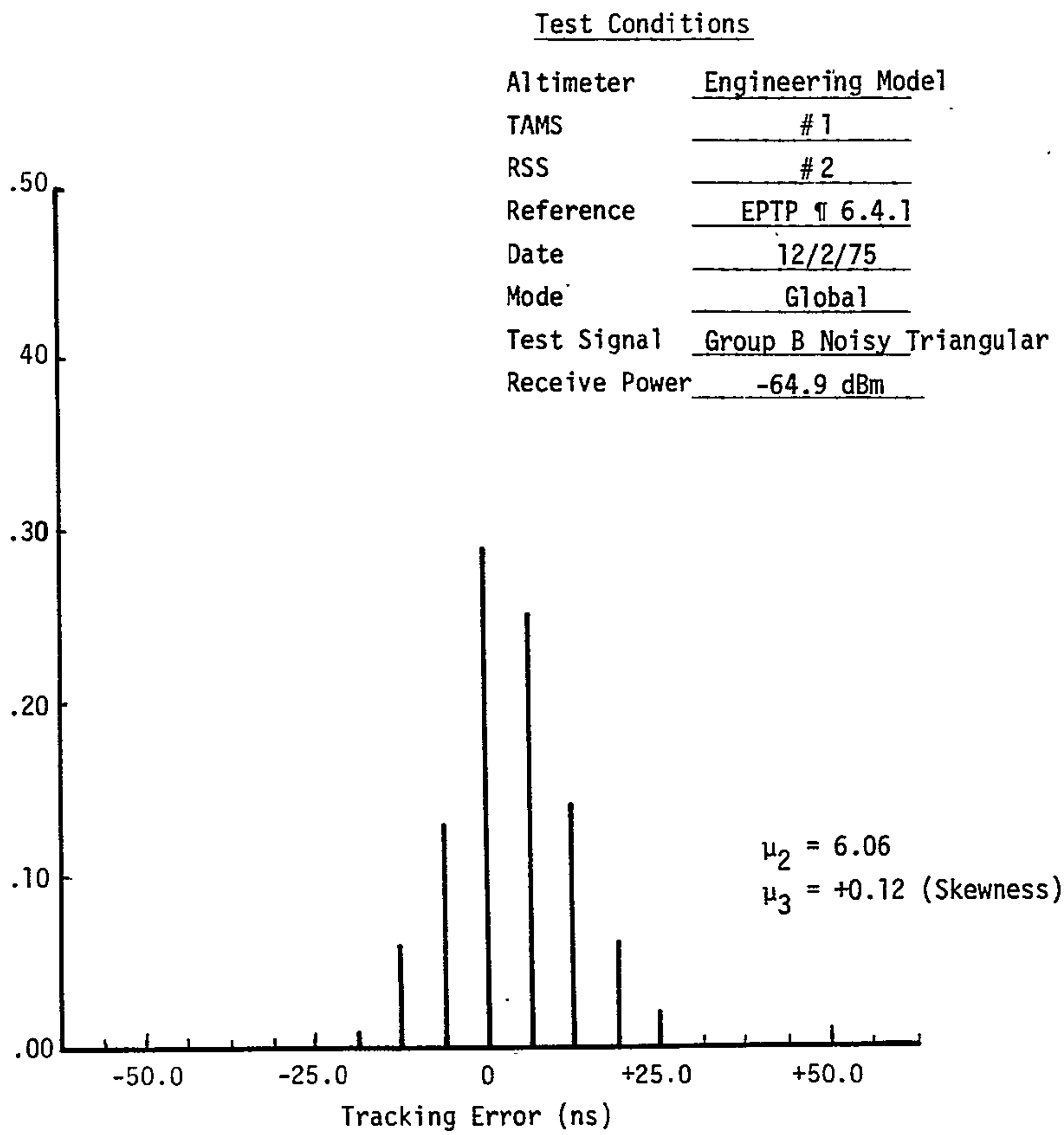


Figure 3.11. Measured Histogram of Pulse-to-Pulse Altitude Error for Global Mode.

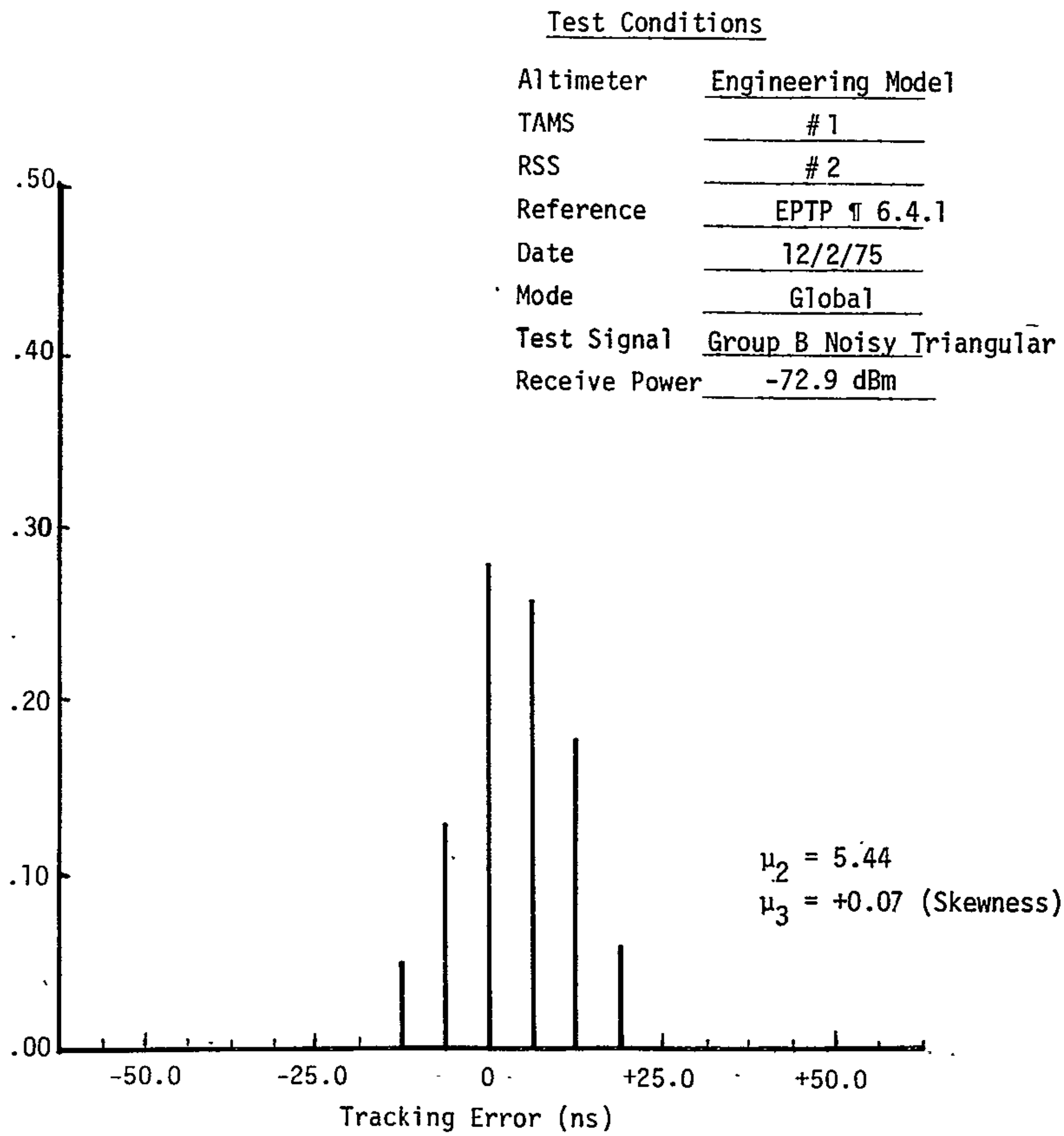


Figure 3.12. Measured Histogram of Pulse-to-Pulse Altitude Error for Global Mode.

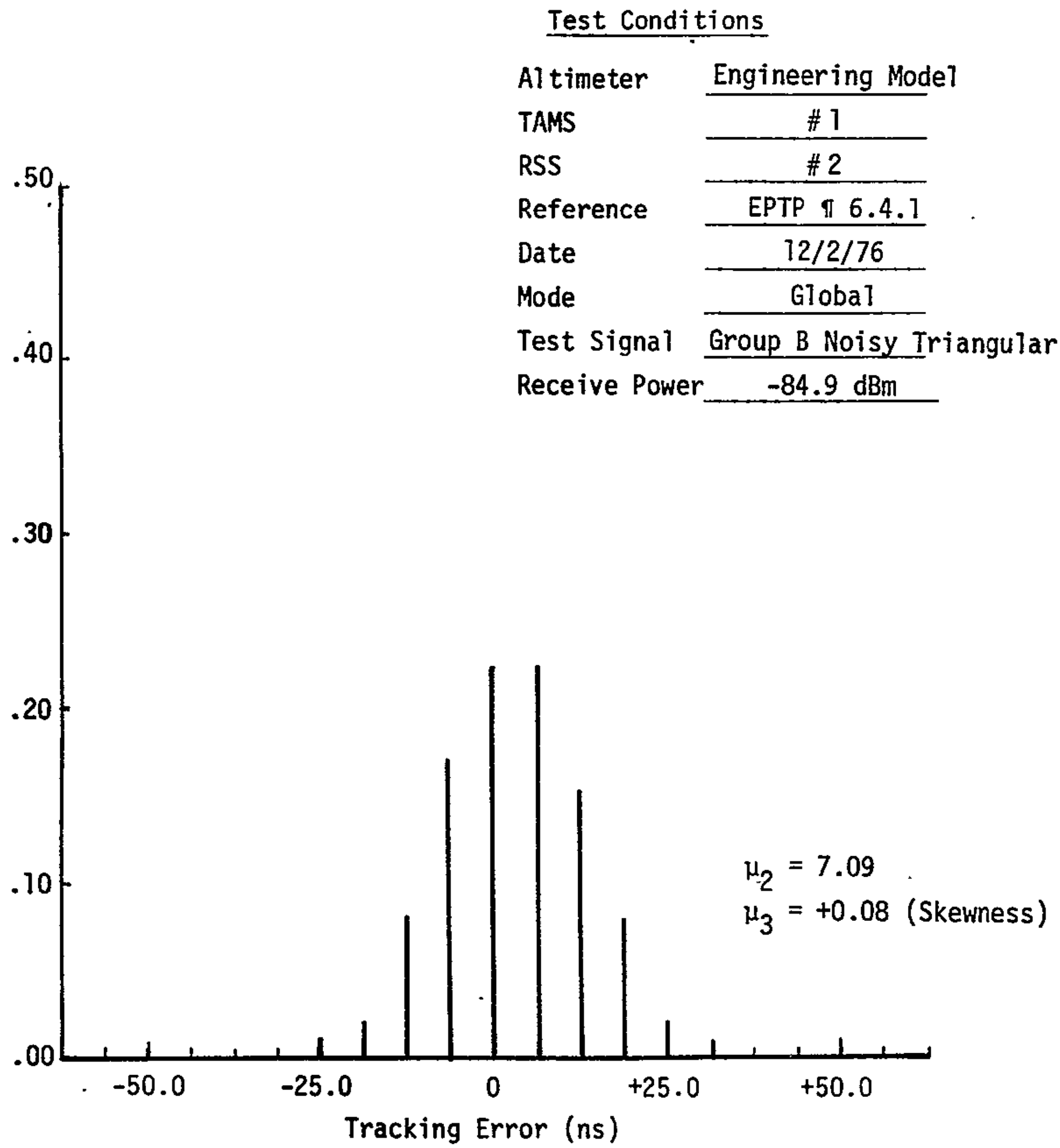


Figure 3.13. Measured Histogram of Pulse-to-Pulse Altitude Error for Global Mode.

$$\zeta = \frac{\Sigma\ n(x)\ x}{N} \qquad \text{and} \qquad (3\text{-}3)$$

$$\mu_2 = \frac{\Sigma\ n(x)x^2}{N} - \zeta^2 \qquad (3\text{-}4)$$

are the first and second central moments, respectively. The number of observations of a single value x is denoted by n(x); and N is the total number of observations, $N = \Sigma n(x)$. Table 3.7, below, summarizes these results for G-Mode.

Received Power (dBm)	Coefficient of Skewness (dimensionless)
-64.9	-0.12
-72.9	-0.071
-84.9	-0.080

Table 3.7. G-Mode Tracking Error PDF Skewness

3.3.2.3 Altitude Bias For Different Received Power Levels

It can be seen from Table 3.1 that the altitude delay is very nearly constant (within 1 nanosecond) as a function of received power for the G-Mode standard test waveform. In addition near-specular waveforms G-1, G-2 and G-3 exhibit similar results as a function of altimeter received power.

3.3.2.4 Tracking Loop Bandwidth as a Function of Received Power

The autocorrelation function (ACF) of the altitude tracker output was used to determine the tracking loop bandwidth for a given test waveform. The Saicor CAPA was used to compute the average autocorrelation function,

$$\overline{R}(n\tau) = \frac{1}{N-\tau} \sum_{n=0}^{N-\tau} x(n)x(n+\tau) \qquad \tau = 0,1,\ldots m \qquad (3\text{-}5)$$

using 100 per second data and 32,768 pulses. The tracking loop power spectral density was estimated by taking the Fourier transform of $\overline{R}(n\tau)$. That is

$$S(m\omega) = \sum_{m=0}^{K-1} R(n\tau)\, e^{-\frac{jn\tau m\omega}{K}} \qquad m = 0,1,\ldots N \qquad (3.6)$$

where K is the number of sample points of spacing τ over which the spectrum was computed.

As an example of this approach consider Figure 3.14 which depicts the G-Mode altitude correlation coefficient from the Saicor ACF. The correlation coefficient is computed from the unnormalized average autocorrelation (equation 3-5) function using

$$\rho(\tau) = \frac{\overline{R}_x(\tau)}{\overline{R}_x(0)}$$

The corresponding power spectral density function (PSD) computed using equation (3-6) is shown in Figure 3.15.

Figures 3.16 and 3.17 show nominal GEOS-III values for the GEOS-III ACF and loop transfer function (magnitude) from [6]. Since for a linear system with input PSD $S_i(\omega)$, transfer function $H(j\omega)$; the output PSD $S_o(\omega)$ is

$$S_o(\omega) = |H(j\omega)|^2\, S_i(\omega)$$

and since the 100/sec loop input signal is uncorrelated, $S_i(\omega)$ is essentially constant over the output frequency range of interest. Therefore

$$S_o(\omega) \simeq |H(j\omega)|^2$$

and Figures 3.15 and 3.17 represent equivalent quantities, i.e., nominal and measured power spectra. Examination of Figure 3.14 shows the engineering model ACF to contain a rather large first side lobe value. This behavior is indicative of a non-monotone frequency response. Figure 3.15 shows this is indeed the case; the system frequency response of the engineering model shows an ~ 5 dB peak compared to a nominal value of ~ 2 dB. Based on this

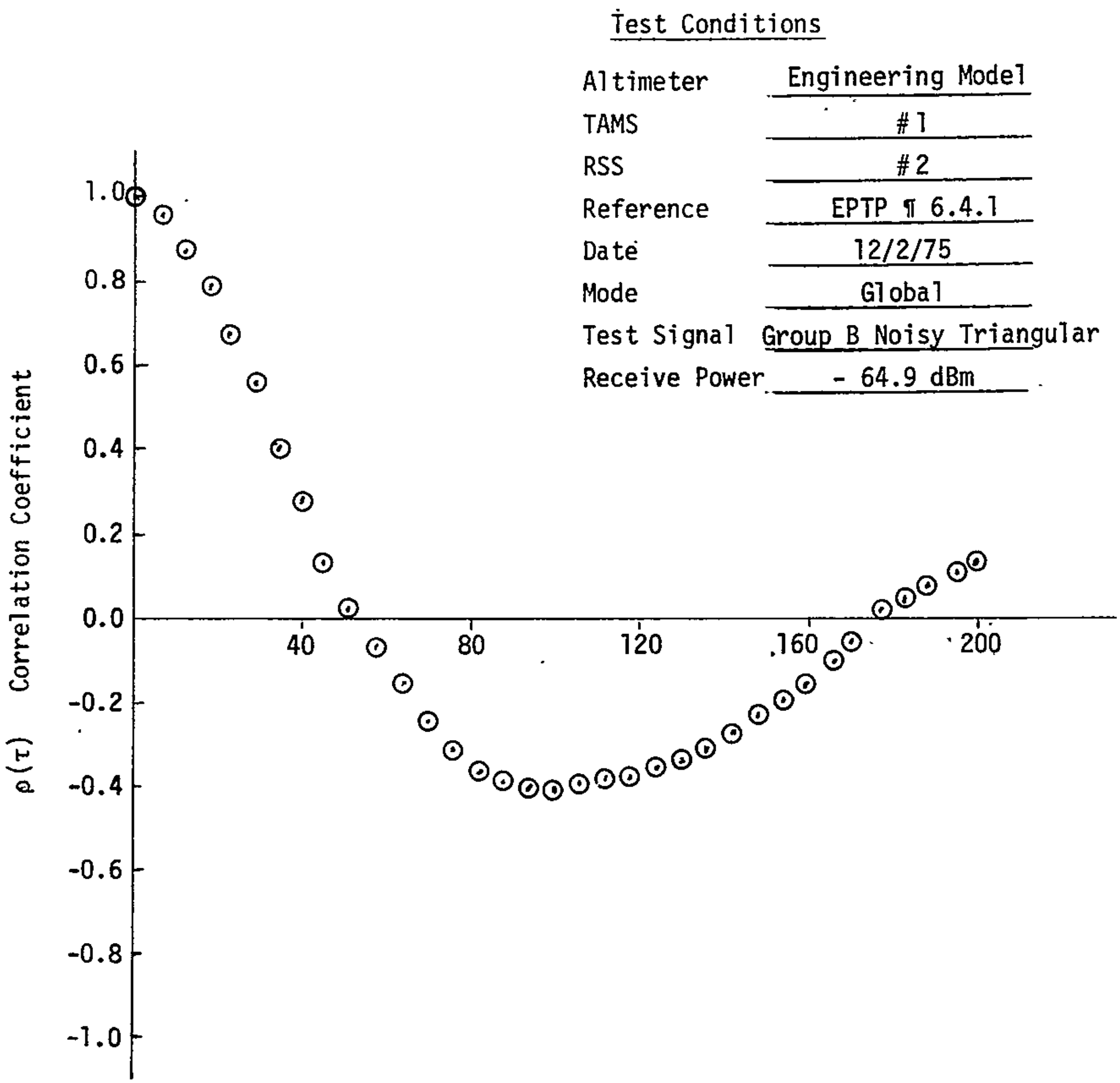


Figure 3.14. **Measured Correlation Coefficient of Random Tracking Error (Integer Multiples of Interpulse Period, T = 10.240 ms).**

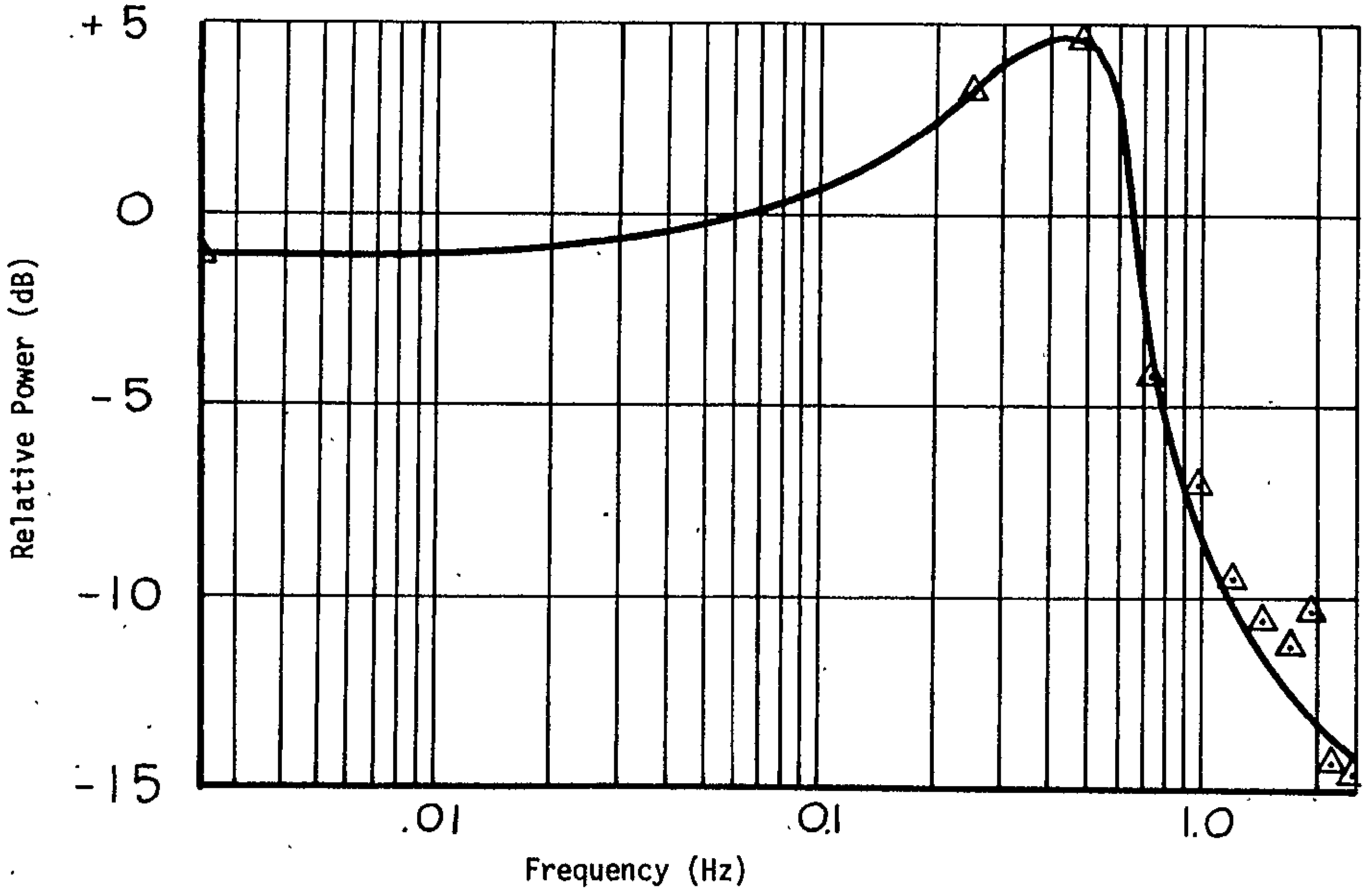


Figure 3.15. G-Mode Power Spectral Density Plot Computed From Measured Correlation Coefficient Using 64-Point FFT and a Hamming window. $P_r = -64.9$ dBm.

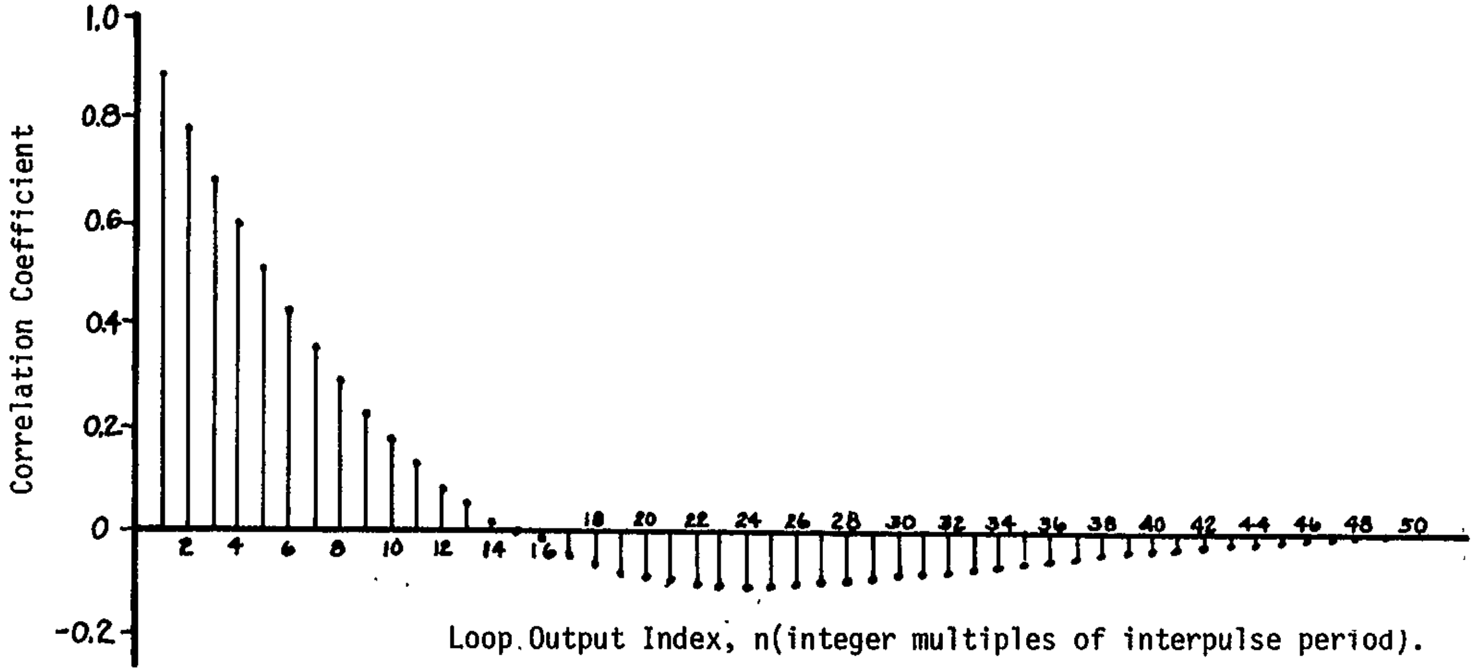


Figure 3.16. Correlation Coefficient of Random Tracking Error (Equivalently, Correlation Coefficient of Random Error in Tracking Loop Output) for Nominal GEOS Design (Intensive and Global Modes).

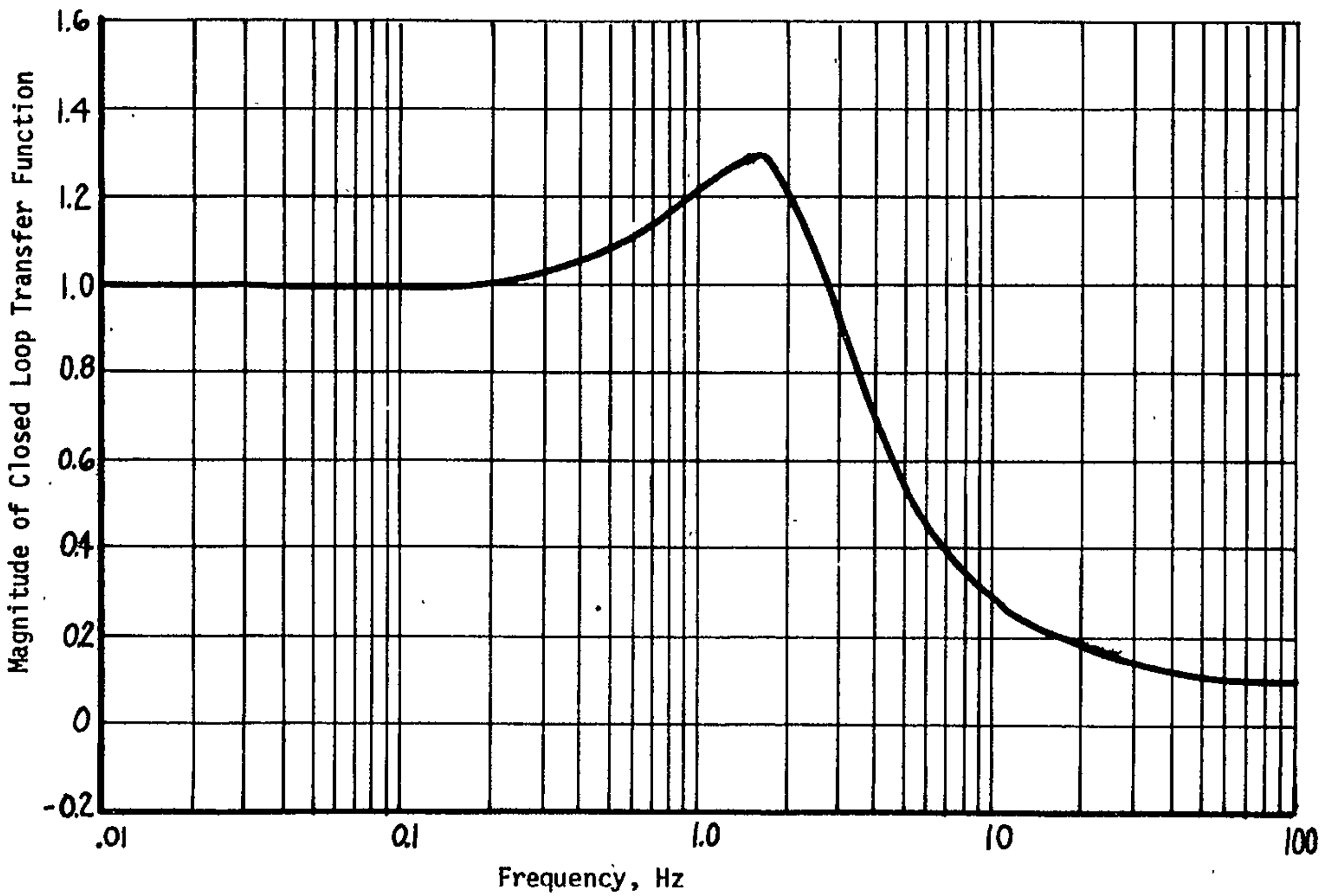


Figure 3.17. Closed Loop Frequency Response for Nominal GEOS Design, from [6].

comparison, it is concluded that the engineering model tracker transfer function is highly under-damped and that the quantitative results should not be extrapolated to infer flight hardware performance.

A 64-point fast Fourier transform (FFT) algorithm with a Hamming window function was used to compute the results shown in Figure 3.15. The Hamming window function was chosen to minimize the effect of high spectrum analyzer filter side lobes.

Using the Hamming spectra, the bandwidths for these test waveforms is on the order of 0.75 to 1.5 Hz. Referring to the ACF, this corresponds approximately to 0.5 to 0.6 times the inverse of the first zero crossing. As a rule of thumb, 0.6 times one over the ACF first zero crossing is used on this data to convert the Saicor ACF data to loop bandwidth. The results are given in Table 3.8 for the Global mode test waveforms.

Selected data from Table 3.8 are plotted as a function of received power in Figure 3.18.

3.3.3 Intensive Mode Results

3.3.3.1 Altitude Jitter Versus Receive Power

Figure 3.19 shows tracking jitter σ_h, versus altimeter receive power for several I-Mode test waveforms. As before, the values measured here apply only to the specific waveshapes used due to receiver saturation effects. The SNR range over which the data were taken is narrow because of power output limitations from the RSS and because the Engineering Model altimeter tracker tends to break lock in the I-Mode at about -75 dBm. However, it can be observed that the measured I-Mode tracker jitter behaves generally as predicted by the theoretical I-Mode tracker jitter curves from the Altimeter Design Error Analysis [6] shown in Figure 3.20.

3.3.3.2 Altitude Error Distribution Versus Receive Power

Figures 3.21 through 3.23 show altitude error PDF's for the standard test waveform for three different receive powers. A quantitative measure of the skewness of these distributions was obtained using equation (3-2). Table 3.9 below summarizes these results.

Test Waveform	Received Power (dBm)	ACF 1st Zero Crossing ($x10^{-2}$ Sec)	Estimated Bandwidth (Hz)	Altitude Jitter σ_h (ns)
Group B Noisy Triangular ↓	-64.9 -68.9 -72.9 -76.9 -80.9 -84.9 -91.9	15.5 16.0 18.0 17.5 15.5 14.5 11.0	0.98 0.95 0.83 0.85 0.98 1.03 1.38	6.15 6.22 6.19 6.33 6.38 6.96 8.98
G-1(τ=275 ns)* ↓	-65.0 -73.0 -81.0 -89.0	10.0 10.0 10.0 8.0	1.50 1.50 1.50 1.88	3.42 3.31 3.60 3.83
G-2(τ=400 ns) ↓	-65.0 -73.0 -81.0 -89.0	18.0 17.5 16.0 12.0	0.83 0.85 0.95 1.25	6.73 6.80 7.11 8.36
G-3(τ=600 ns) ↓	-65.0 -73.0 -81.0 -89.0	17.5 17.5 17.0 13.0	0.85 0.85 0.85 1.15	7.03 7.30 7.45 8.90
G-4(τ=700 ns)	-65.0	17.5	1.85	7.65
G-6(τ=300 ns)	-65.0	11.0	1.35	3.79
G-7(τ=350 ns)	-65.0	16.5	0.90	6.16
G-8(τ=362 ns)	-65.0	11.0	1.35	5.04
G-9(τ=375 ns)	-65.0	15.0	1.00	5.45
G-10(τ=325 ns) ↓	-65.0 -77.0 -89.0	12.5 12.0 10.0	1.20 1.25 1.50	4.62 4.95 5.21
G-11(τ=1325 ns)	-65.0	16.0	0.95	7.12
G-12(τ=600 ns)	-65.0	15.5	0.98	6.92
G-13(τ=500 ns)	-65.0	16.0	0.95	7.15

Table 3.8. Global Mode Tracking Loop Bandwidth and Altitude Jitter

*See Figures 2 through 5 for details of input waveform shape.

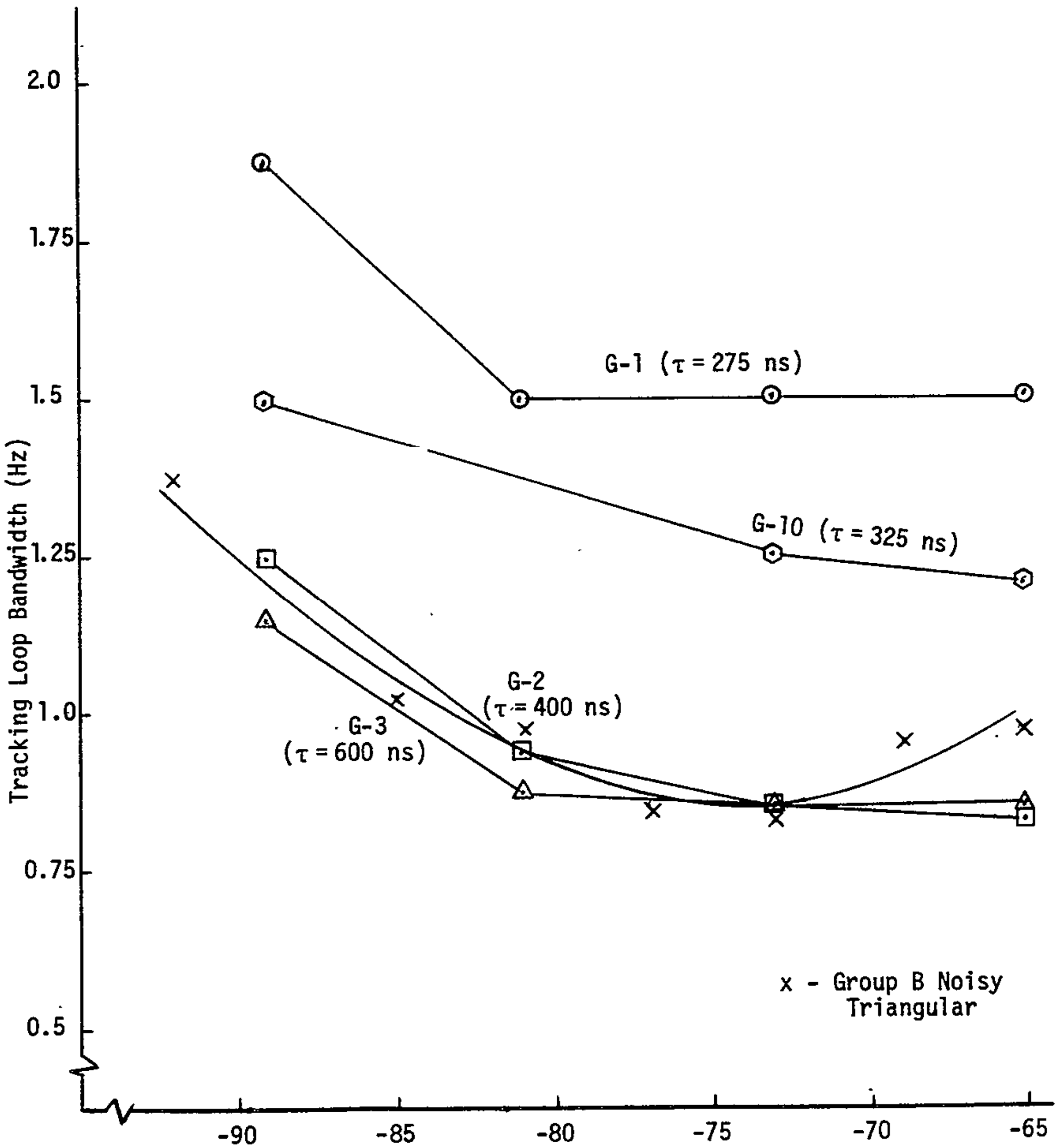


Figure 3.18. G-Mode Tracking Loop Bandwidth
Versus Received Power.

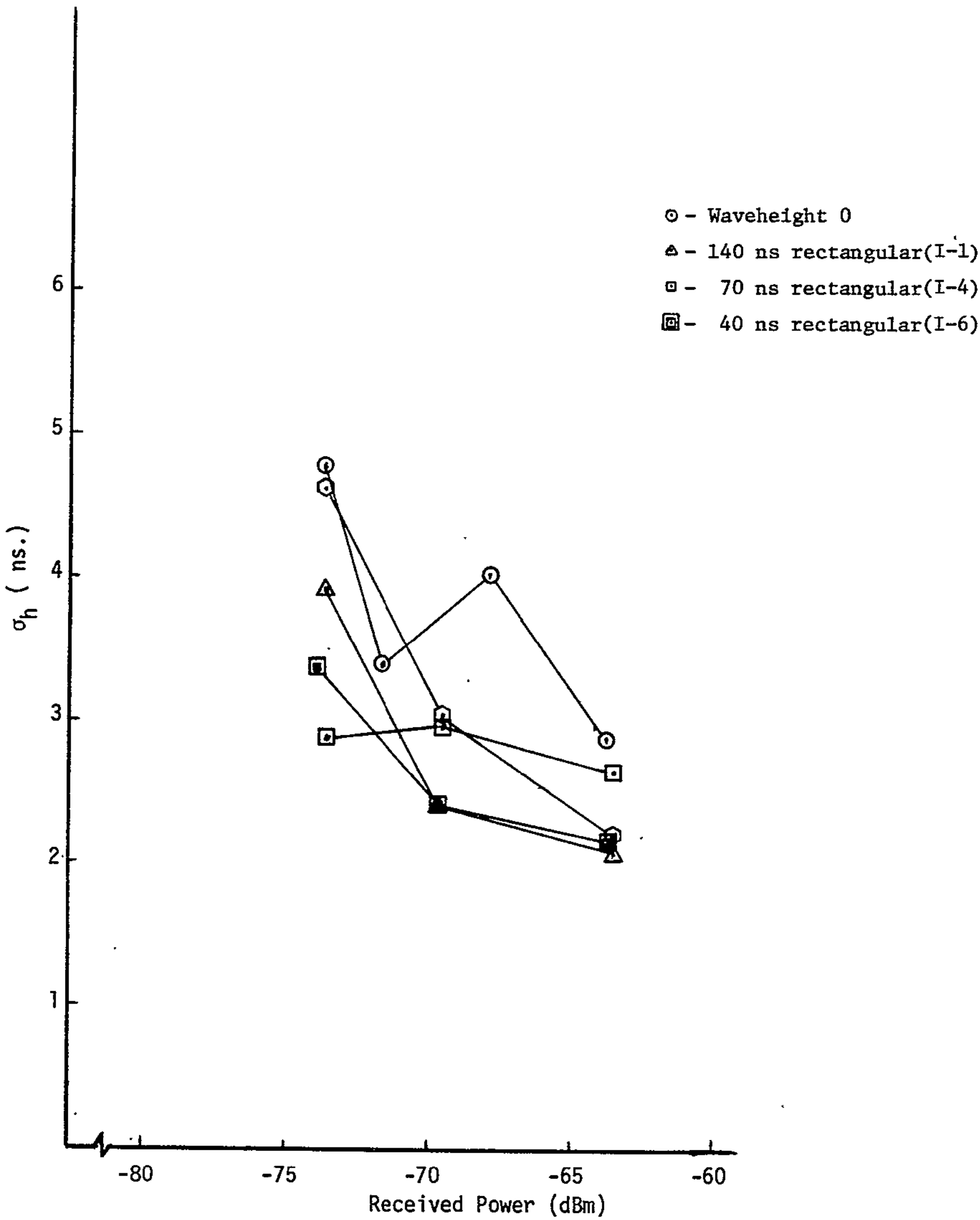


Figure 3.19. I-Mode Altitude Jitter Versus Receive Power

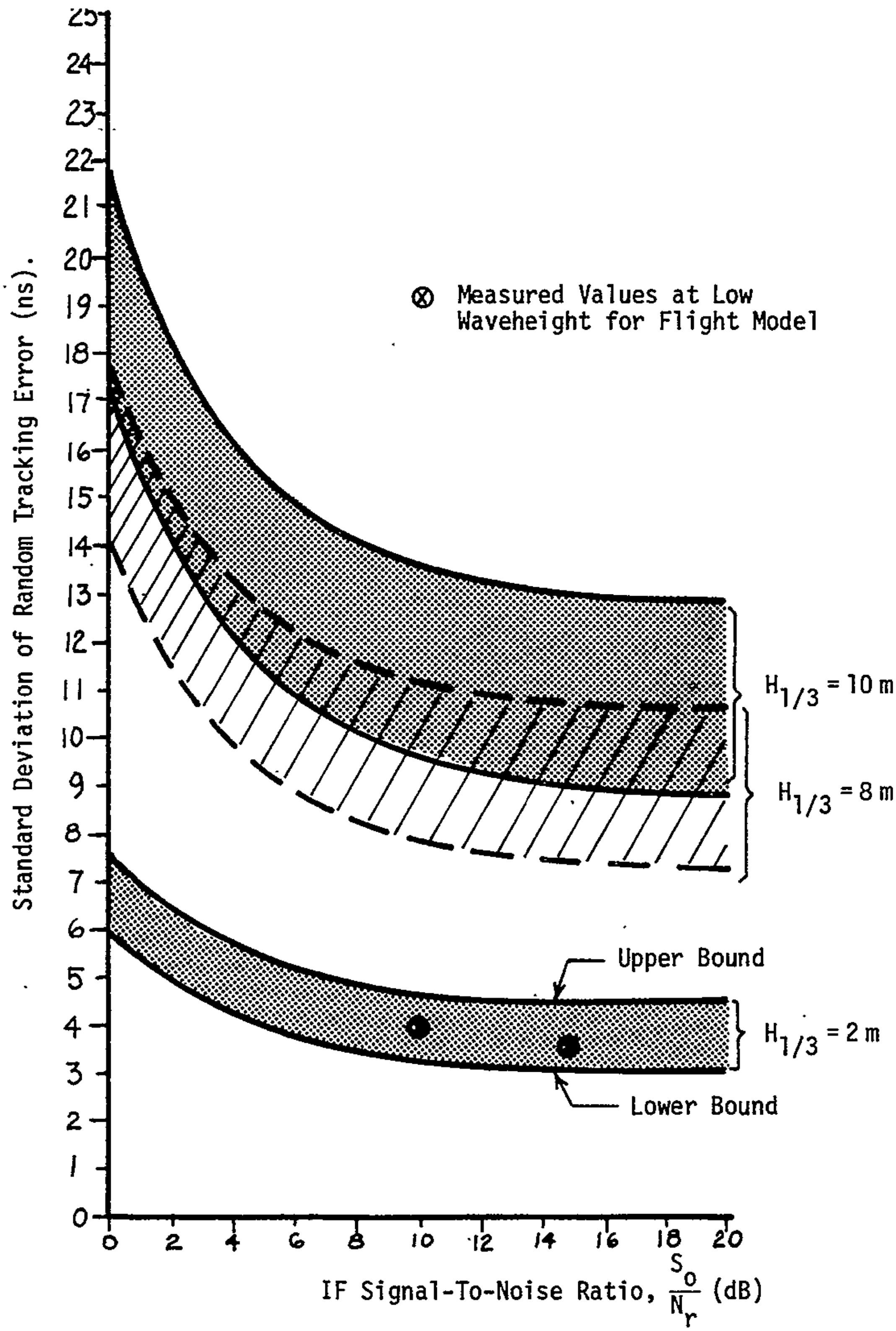


Figure 3.20. Intensive Mode Tracking Error Performance versus Signal-to-Noise Ratio for Different Values of Significant Ocean Waveheight, from [6].

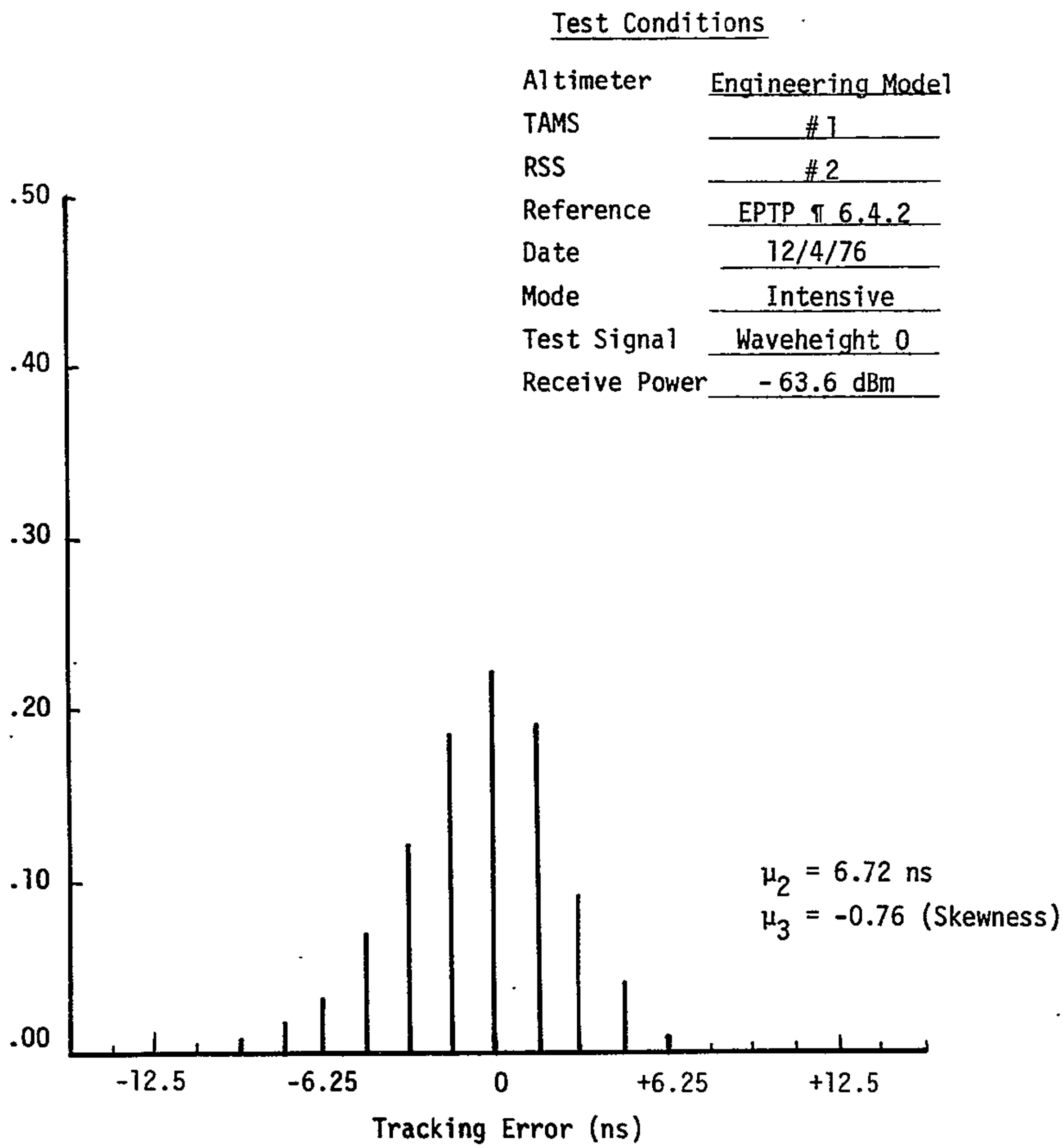


Figure 3.21. Measured Histogram of Pulse-to-Pulse Altitude Error for Intensive Mode.

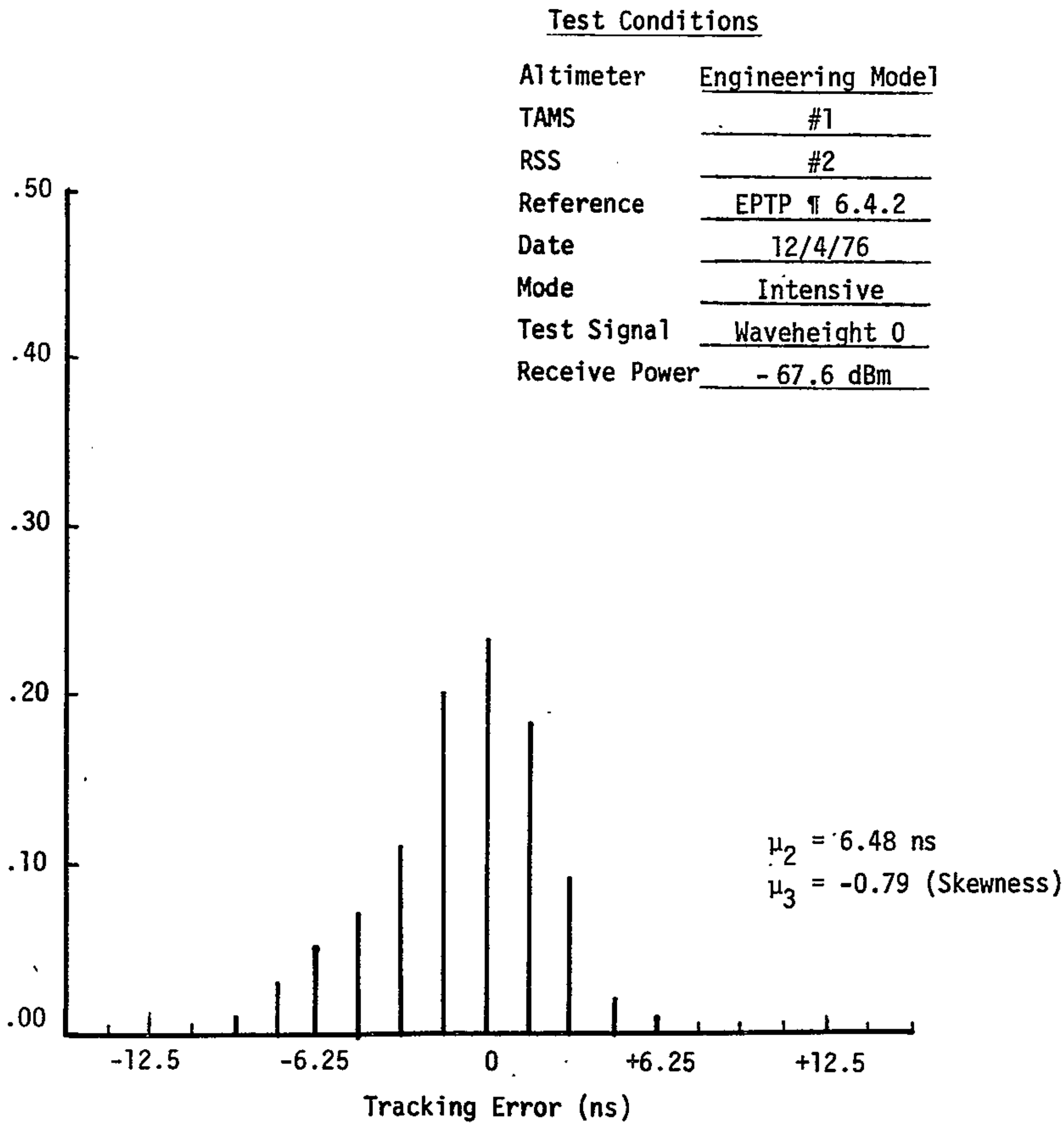


Figure 3.22. Measured Histogram of Pulse-to-Pulse Altitude Error for Intensive Mode.

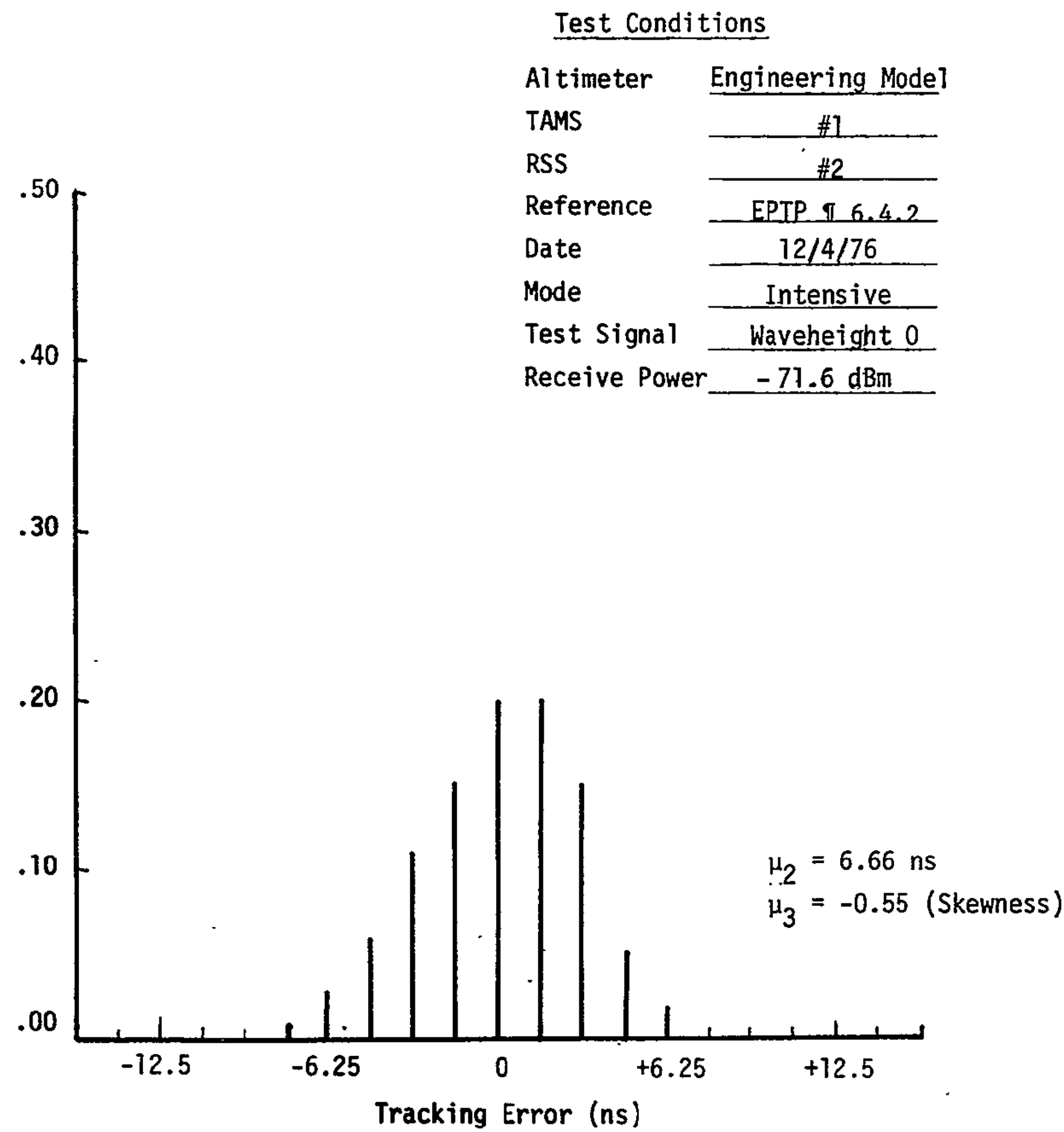


Figure 3.23. Measured Histogram of Pulse-to-Pulse Altitude Error for Intensive Mode.

Received Power (dBm)	Coefficient of Skewness (dimensionless)
-63.6	-0.76
-67.6	-0.79
-71.6	-0.55

Table 3.9. I-Mode Tracking Error PDF Skewness

Comparison of the G-Mode tracking error PDF skewness (Table 3.8) with the I-Mode tracking error PDF skewness shows about an order of magnitude more skewness in the I-Mode case for low SNR's.

3.3.3.3 Altitude Bias For Different Receive Power Levels

Table 3.4 shows that the altitude delay varies 1 to 2 nanoseconds as a function of receive power for the I-Mode standard test waveform. Also for the non-standard test pulse widths (I-5, I-4 and I-1) the altitude delay variation is on the order of 1 to 2 nanoseconds as a function of altimeter received power.

3.3.3.4 Tracking Loop Bandwidth as a Function of Receive Power

The I-Mode tracking loop bandwidth was computed using the Fourier transform of the autocorrelation function approach described in section 3.3.2.4. Figure 3.24 depicts an example I-Mode altitude error correlation as computed by the Saicor analyzer. The resulting PSD was computed using equation 3-6 and is shown in Figure 3.25. A summary of the resulting I-mode bandwidths is given in Table 3.10.

4.0 EMA AGC TESTS

4.1 AGC Calibration

4.1.1 General

The AGC calibration for the Engineering Model altimeter was done to provide current calibration data for use with the other tests on AGC loop and tracker loop response to changing input pulse powers as well as for

Test Conditions

Altimeter	Engineering Model
TAMS	#1
RSS	#2
Reference	EPTP ¶ 6.4.2
Date	12/4/75
Mode	Intensive
Test Signal	Waveheight 0
Receive Power	-63.6 dBm

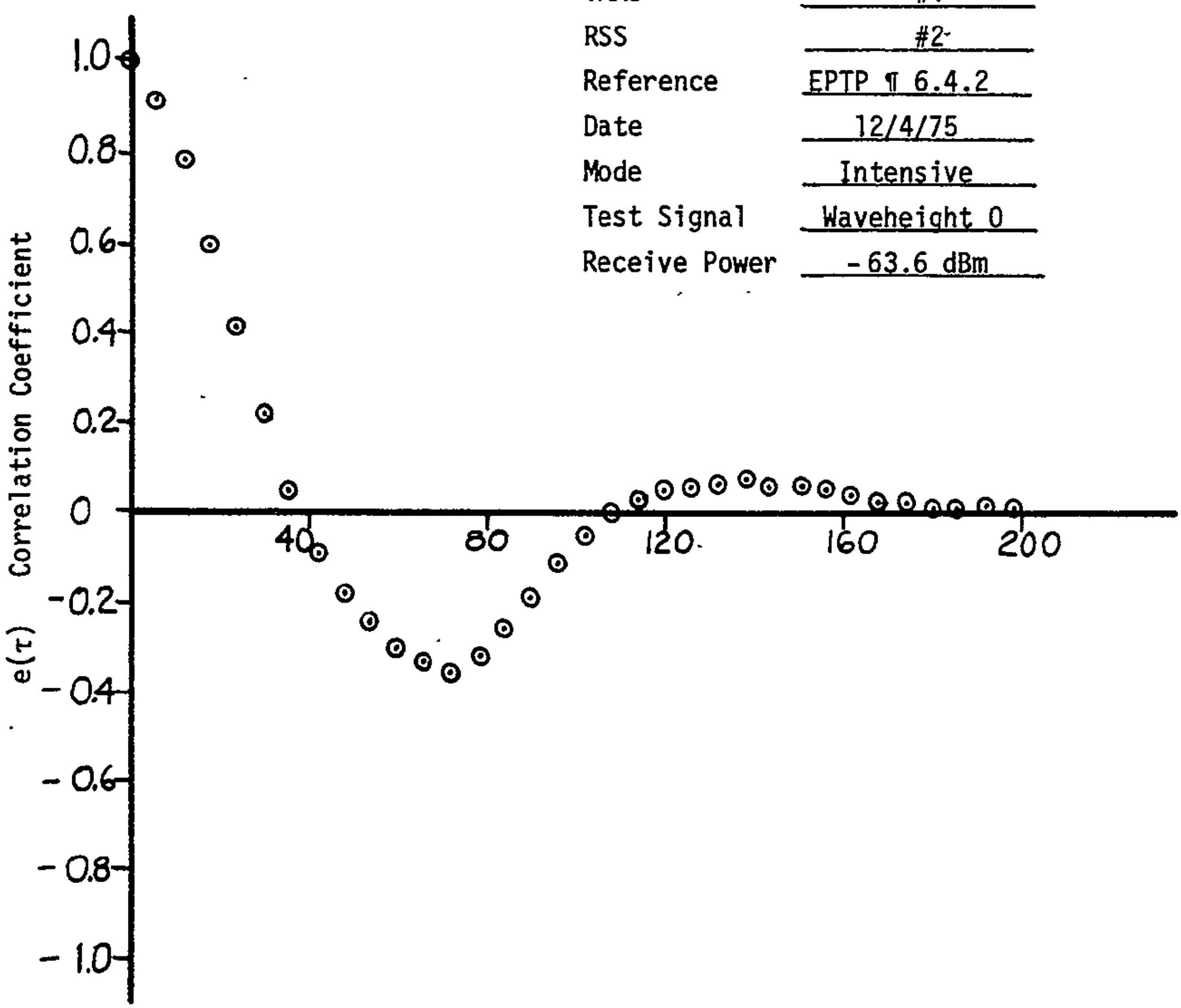


Figure 3.24. Measured Correlation Coefficient of Random Tracking Error (Integer Multiples of Interpulse Period, $T = 10.240$ ms).

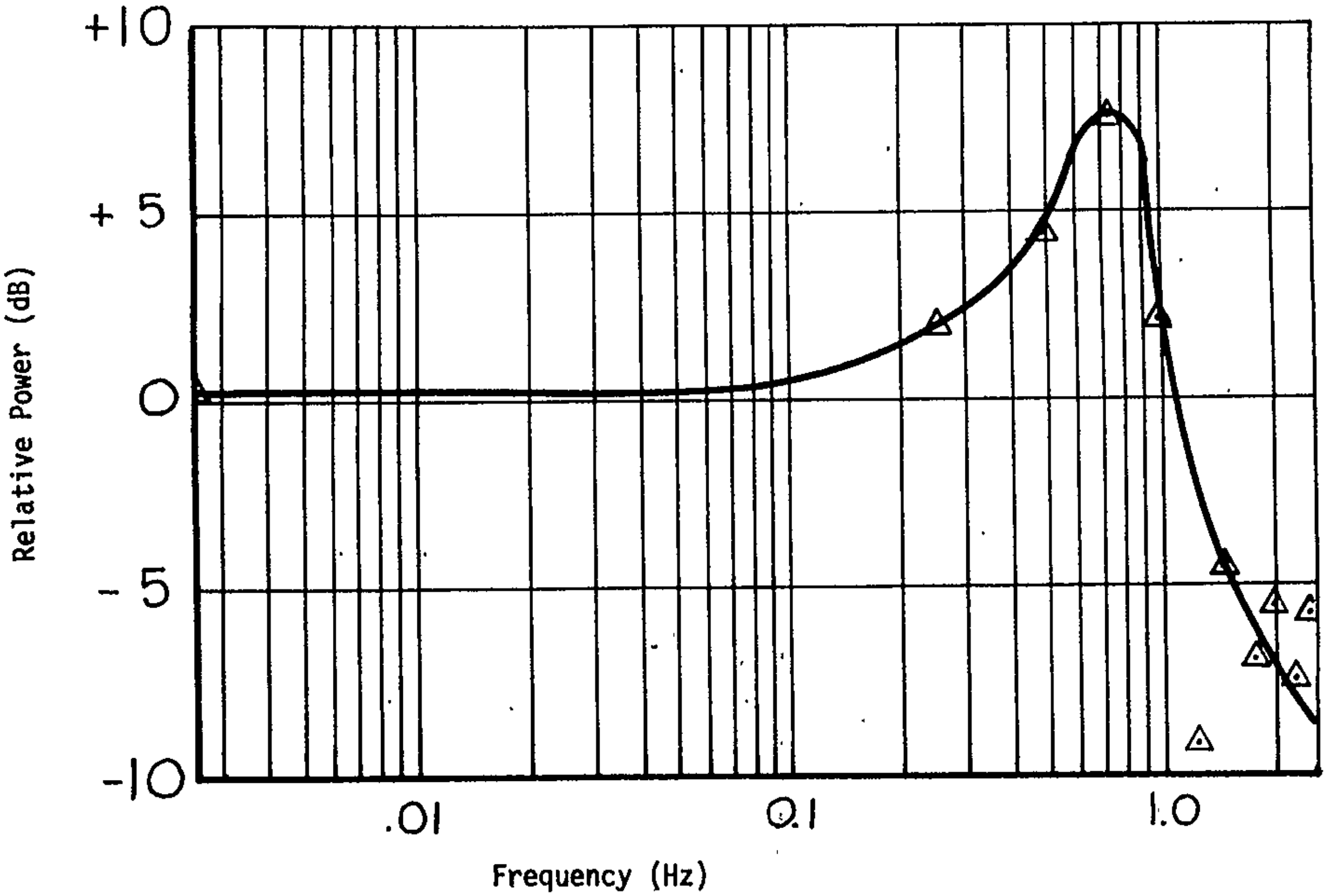


Figure 3.25. I-Mode Tracking Loop Frequency Response Computed From Measured Correlation Coefficient Using 64-Point FFT and a Hamming window. $P_r = -67.6$ dBm.

Test Waveform	Received Power (dBm)	ACF 1st Zero Crossing ($x10^{-2}$ sec)	Estimated Bandwidth (Hz)	Altitude Jitter σ_h (ns)
Group C Noisy Rectangular (Waveheight "0")	-63.6 -67.6 -71.6 -73.6	9.5 11.0 9.5 11.0	1.58 1.38 1.58 1.38	2.86 4.00 3.39 4.70
I-1(τ=40 ns)	-63.6	4.0	3.75	4.84
I-1.5(τ=45 ns)	-63.6	-	-	1.70
I-2(τ=50 ns)	-63.6	6.0	2.50	1.70
I-3(τ=60 ns)	-63.6	9.0	1.68	1.70
I-4(τ=70 ns)	-63.6	9.0	1.68	2.02
I-5(τ=140 ns)	-63.6	11.0	1.38	3.12
I-6(τ=40 ns)	-63.6	5.0	3.00	2.02
I-7(τ=35 ns)	-63.6	4.0	3.75	2.25

Table 3.10. Intensive Mode Tracking Loop Bandwidth and Altitude Jitter

comparison with earlier GE test data, to check out the modifications in the EPTP procedure to use in Protoflight Model testing, and to shed additional light on the "clean vs. clutter" question for Intensive Mode calibration. An important limitation to the TAMS RSS is the saturation which occurs at higher IF levels into the upconverter, the A14 MIXER, and the decision about what signal level to allow at this point changed as the Engineering Model work progressed. After a further discussion of the upconverter saturation and various data related to that effect, preliminary results are presented for AGC calibration in the Engineering Model's Intensive Mode only (as the -5 V power supply failure terminated this phase before new Global AGC calibration data were obtained).

4.1.1.1 Upconverter Saturation

Of the very large variety of simulated return pulses possible from TAMS RSS settings and interconnections, there are seven "standard" EPTP-specified pulses whose properties are summarized briefly in Table 4.1. Also a Group B, noisy, rectangular pulse has been added to this summary; this non-EPTP-specified signal was used in Global Mode altitude tracker and AGC loop measurements. Common to all of these specified signal setups is the RF/IF/-STATISTICS LEVEL ADJ., a switch-type attenuator which precedes the IF-to-RF upconverter, MIXER A14. The IF calibrated peak power level denoted IFCPPL and measured as specified in EPTP section 9, is a function of the RF/IF/-STATISTICS setting as is the RF calibrated peak power level, RFCPPL again measured as specified in the EPTP.

In Tables 4.2 through 4.6, data are presented from the recent Engineering Model tests for RFCPPL and IFCPPL vs. RF/IF/STATISTICS setting for the Group B triangular signal setup for rf clean and noisy, for modified Group B triangular† rf noisy, and for Group C rectangular rf clean and noisy signals. The important results from these measurements are the RFCPPL vs. IFCPPL curves as shown in Figures 4.1 - 4.2. These RFCPPL vs. IFCPPL results show

†This "modified triangular" group B noisy is in fact the same signal set up as the group B noisy rectangular pulse used; the only change from rectangular to triangular shape is in the modulation waveform out of the EH Pulse Generator, and in AGC calibration this is replaced by the BIAS output at the TAMS RSS anyhow. (See EPTP 6.3.2.)

Table 4.1. Summary of TAMS RSS signals, and EPTP-specified settings of the Noise/Sinewave, Noise Mod., and RF/IF/Statistics attenuators. Filter Bandwidth #1 except as noted. ASA-recommended RF/IF/Statistics attenuator settings are in general 7 dB greater than the values listed below.

		RECTANGULAR	TRIANGULAR
Group B Signals (for G-Mode)	CLEAN	Modulation Network B2 Noise/Sinewave = 32 dB RF/IF/Statistics = 17 dB EPTP Para. 9.2.2	Modulation Network B1 Noise/Sinewave = 25 dB RF/IF/Statistics = 21 dB EPTP Para. 9.2.1
	NOISY	Modulation Network B2 Noise/Sinewave - 17 dB No EPTP-specified procedure, ASA setting of RF/IF/Statistics = 16 dB	Modulation Network B3 Noise/Sinewave = 17 dB RF/IF/Statistics = 2 dB EPTP Para. 9.2.3
Group C Signals (for I-Mode)	CLEAN	No Modulation Network Noise/Sinewave = 20 dB RF/IF/Statistics = 20 dB EPTP Para. 9.3.1	No EPTP-specified procedure
	NOISY	WAVEHEIGHT 0 No Modulation Network Noise/Sinewave = 13 dB Noise mod. = 9 dB RF/IF/Statistics = 12 dB EPTP Para. 9.3.2	WAVEHEIGHT 1 Modulation Network B3 (Filter Bandwidth #3) Noise mod. = 7 dB RF/IF/Statistics = 9 dB EPTP Para. 9.3.3 WAVEHEIGHT 2 Modulation Network B3 Noise/Sinewave = 11 dB Noise mod. = 7 dB RF/IF/Statistics = 9 dB EPTP Para. 9.3.4

Table 4.2. RFCPPL and IFCPPL vs. RF/IF/STATISTICS Attenuator Setting for Group B, Triangular, RF Noisy Signal as per EPTP 9.2.3 (Two different sets of data are given below, obtained on different days).

RF/IF/STATISTICS Attenuator Setting, in dB	IFCPPL, Measured, in dBm	RFCPPL, Measured, in dBm
0	-0.9 dBm	-18.4 dBm
1	—	-19.1
2	-2.9	-19.9
4	-4.8	-21.4
6	-6.9	-23.2
8	-8.9	-25.1
10	-10.9	-27.0
12	-12.9	-29.0
0	-0.5 dBm	-18.0 dBm
2	-2.4	-19.4
4	-4.4	-21.0
6	-6.5	-22.8
8	-8.5	-24.6
10	-10.5	-26.6
12	-12.5	-28.5
14	-14.4	-30.5

Table 4.3. RFCPPL and IFCPPL vs. RF/IF/STATISTICS Attenuator Setting for Group, B Modified Triangular, RF Noisy, Differs from EPTP 9.2.3 by Input To Network B2.

RF/IF/STATISTICS Attenuator Setting, in dB	IFCPPL, Measured, in dBm	RFCPPL, Measured, in dBm
0 dB	+6.9 dBm	-14.9 dBm
2	4.9	-15.5
4	3.0	-16.2
6	0.9	-17.2
8	-1.0	-18.5
10	-3.0	-20.0
12	-5.0	-21.6
14	-7.0	-23.2
16	-9.1	-25.2
18	-11.0	-27.1

Table 4.4. RFCPPL and IFCPPL vs. RF/IF/STATISTICS Attenuator Setting for Group B, Triangular, RF Clean Signal as per EPTP 9.2.1

RF/IF/STATISTICS Attenuator Setting, in dB	IFCPPL, Measured, in dBm	RFCPPL, Measured, in dBm
9 dB	+8.9 dBm	-13.8 dBm
11	6.8	-14.0
13	4.9	-14.4
15	2.9	-15.2
17	0.8	-16.3
19	-1.0	-17.8
21	-3.3	-19.7
23	-5.2	-21.4
25	-7.2	-23.3
27	-9.2	-25.3
29	-11.2	-27.1
31	-13.3	-29.4
33	-15.2	-31.2
35	-17.2	-33.5
37	-19.3	-36.0

Table 4.5. RFCPPL and IFCPPL vs. RF/IF/STATISTICS Attenuator Setting for Group C, Rectangular, Waveheight 0, RF Clean Signal as per EPTP 9.3.1

RF/IF/STATISTICS Attenuator Setting, in dB	IFCPPL, Measured, in dBm	RDCPPL, Measured, in dBm
10 dB	+7.2 dBm	-14.0 dBm
12	+5.4	-14.4
14	+3.4	-15.0
16	+1.2	-16.1
18	-0.6	-17.5
20	-2.6	-19.2
22	-4.6	-21.0
24	-6.6	-22.8
26	-8.8	-24.6
28	-10.7	-26.8
30	-12.8	-28.9
32	-14.8	-30.7

Table 4.6. RFCPPL and IFCPPL vs. RF/IF/STATISTICS Attenuator Setting for Group C, Rectangular, Waveheight 0, RF Noisy Signal as per EPTP 9.3.2

RF/IF/STATISTICS Attenuator Setting, in dB	IFCPPL, Measured, in dBm	RFCPPL, Measured, in dBm
1 dB	+9.2 dBm	-15.1 dBm
3	7.2	-15.4
5	5.3	-16.0
7	3.4	-16.7
9	1.3	-17.6
11	-0.6	-18.8
13	-2.6	-20.2
15	-4.6	-21.0
16	—	-22.7
17	-6.6	-23.6
19	-8.6	-25.5
21	-10.6	-27.3
23	-12.7	-29.4
25	-14.7	-31.2

Figure 4.1. RF Calibrated Peak Power RFCPPL vs. IF Calibrated Peak Power IFCPPL for RF Clean and RF Noisy Group B Triangular Signals

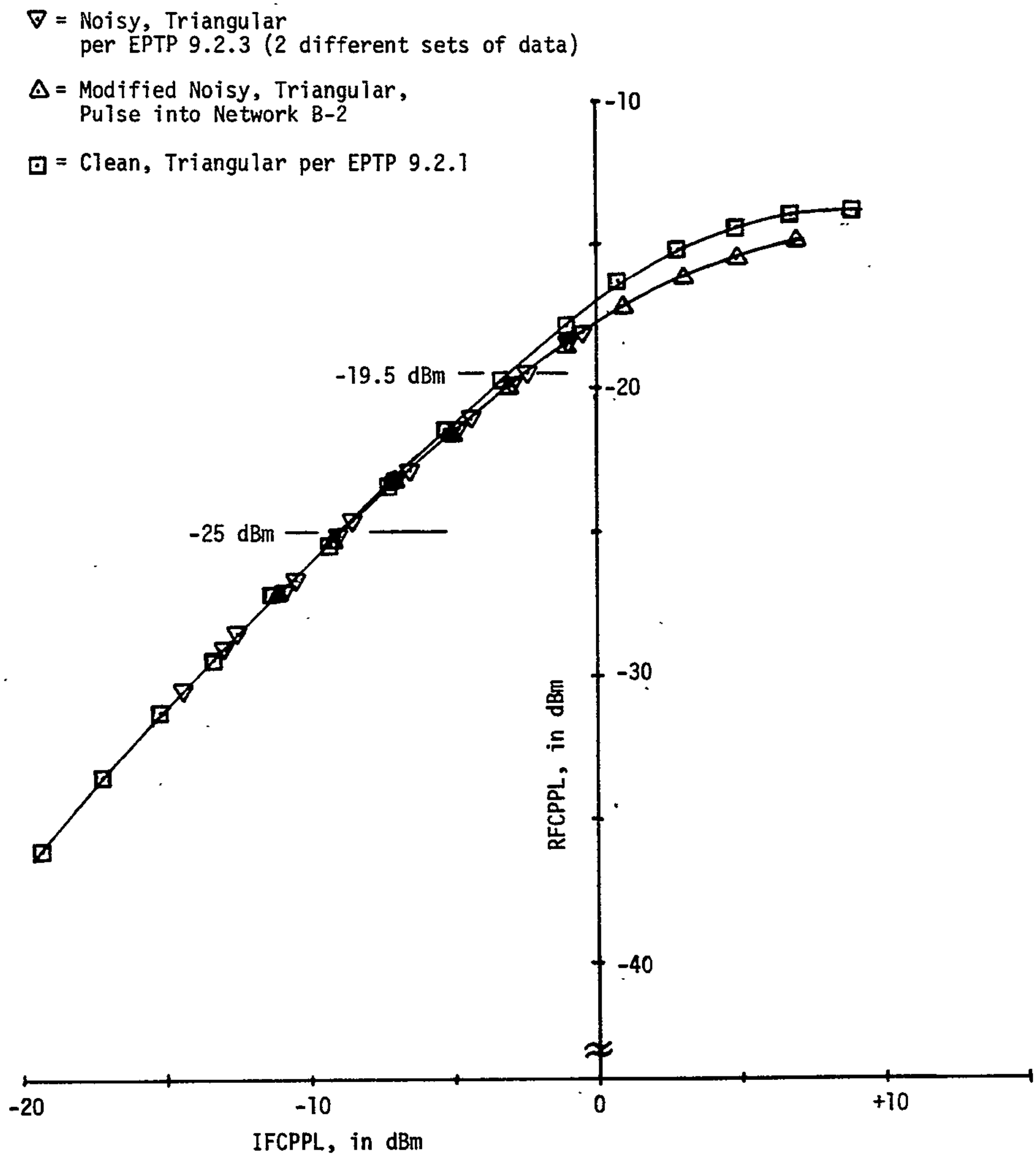
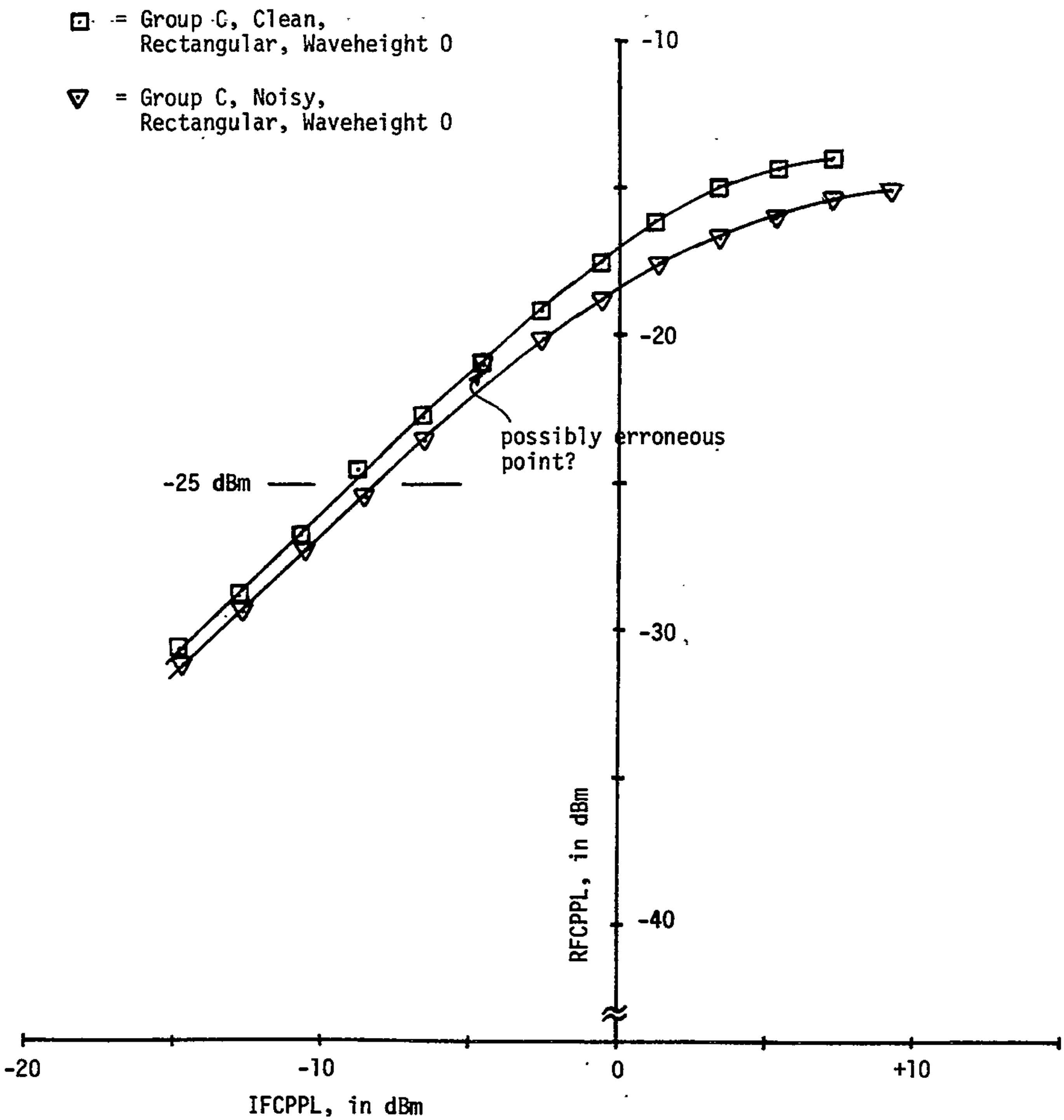


Figure 4.2. RF Calibrated Peak Power, RFCPPL, vs. IF Calibrated Peak Power IFCPPL For RF Clean and RF Noisy Group C Rectangular, Waveheight 0 Signals.



principally the behavior of the A14 MIXER upconverter; the solid lines of the two preceding Figures are replotted in Figure 4.3; the saturation of the upconverter (evidenced by the departure from linearity for RFCPPL > -25 dBm) and also that for RFCPPL < -25 dBm the Group C noisy curve is appreciably different from all other results which tend to merge into one curve.

That the departure from linearity of RFCPPL vs. IFCPPL is upconverter saturation is verified by examining Tables 4.2 - 4.6 which show IFCPPL vs. RF/IF/STATISTICS as a straight line even when RFCPPL vs. RF/IF/STATISTICS departs from linearity. In general, the EPTP-specified signal setup procedures set IFCPPL at around -19.5 dBm for all GE testing of the different altimeter models. Keeping RFCPPL at this level supplied "proper drive level" (according to GE) at the upconverter mixer; also levels below -30 dBm are more difficult to measure with the TAMS power meter. It is felt on the basis of this recent work, however, that a requirement of -26 dBm ≤ RFCPPL ≤ -25 dBm would be a safer, more conservative operating point. The two levels of -19.5 dBm and -25 dBm are noted in the summary Figure 4.1.

Both RFCPPL and IFCPPL are measured with the same HP power meter which should be a true rms power-measuring device; the appearance of more than one curve in Figure 4.1 is therefore disquieting and is probably related to the clean vs. clutter problem. This must be further explored and, since it is a TAMS-only phenomenon at first level, it will not require additional operating time on the Protoflight Model.

4.1.2 Intensive Mode AGC Calibration

The procedure carried out was a modification of that in EPTP paragraph 6.3.2. This AGC calibration was carried out before the importance of RFCPPL vs. IFCPPL had been fully appreciated and as a result the two sets of data presented here violate the already discussed requirement of -26 dBm < RFCPPL < -25 dBm.

Tables 4.7 and 4.8 present the results from the two Group C signals used; the two signals were the rf clean and rf noisy versions of a rectangular, waveheight 0 pulse, set up as per EPTP 9.3.1 and 9.3.2 respectively except that the RF/IF/STATISTICS was set at 16 dB for both. These data are also plotted for comparison on the same scale in Figure 4.4, and the

Figure 4.3. Summary of RFCPPL vs. IFCPPL Results from Figures 4.1 and 4.2.

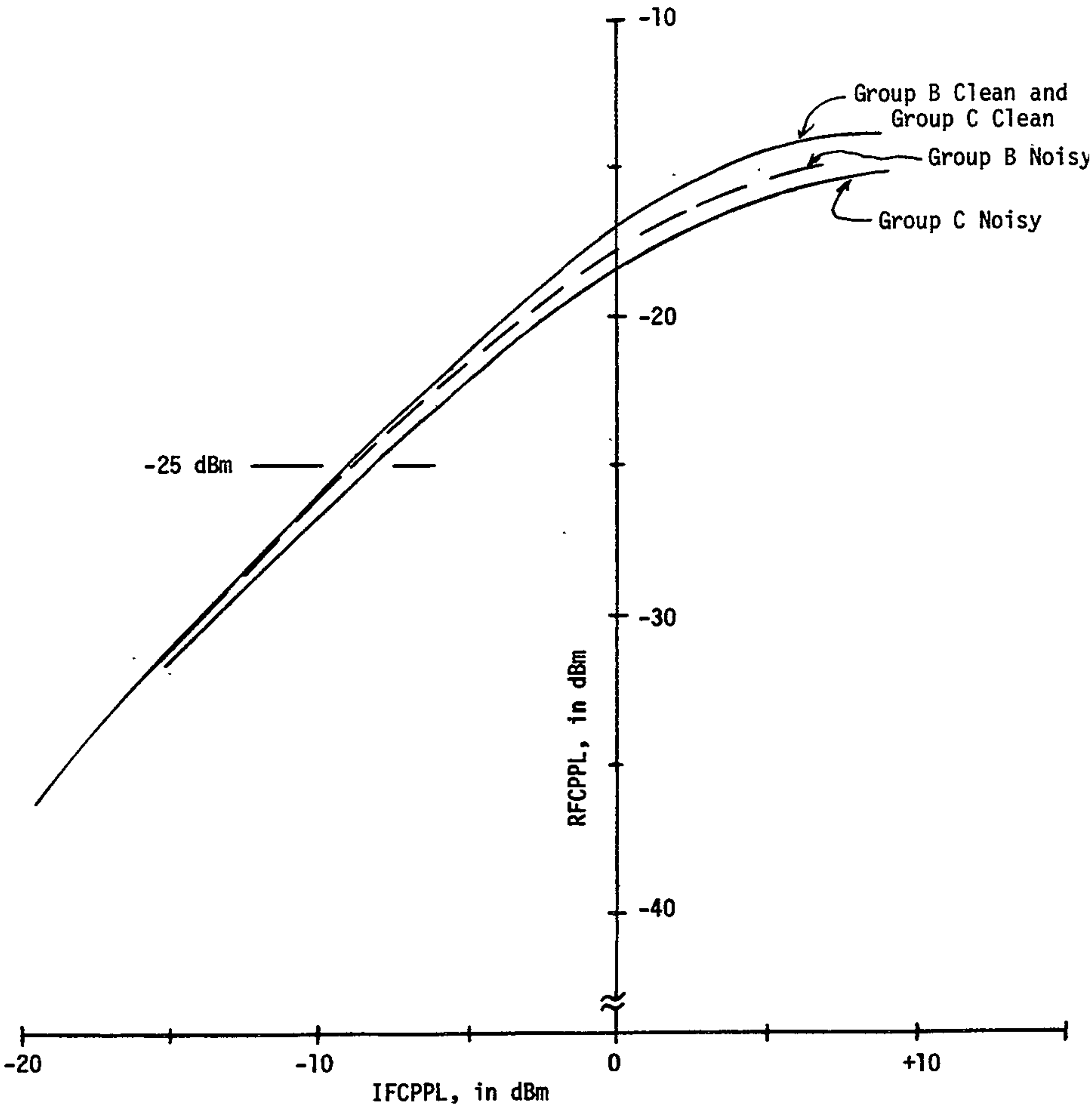


Table 4.7. Engineering Model AGC Calibration Results for Group C RF NOISY, Rectangular, Waveheight 0 Signals.

Signal Setup: As per EPTP Para. 9.3.2 except that RF/IF/STATISTICS = 16 dB.

Measured RFCPPL = -23.7 dBm

CCV + WG: = 39.8 dB

RF OUTPUT LEVEL ADJ.	Calibrated Test Input Signal Power	Received Signal V(AGC) in volts (mean of 10 readings)
0 dB	-63.5 dBm	+0.099 V
3	-66.5	-0.223
6	-69.5	-0.655
9	-72.5	-1.072
12	-75.5	-1.888

Table 4.8. Engineering Model AGC Calibration Results for Group C RF Clean, Rectangular, Waveheight 0 Signals.

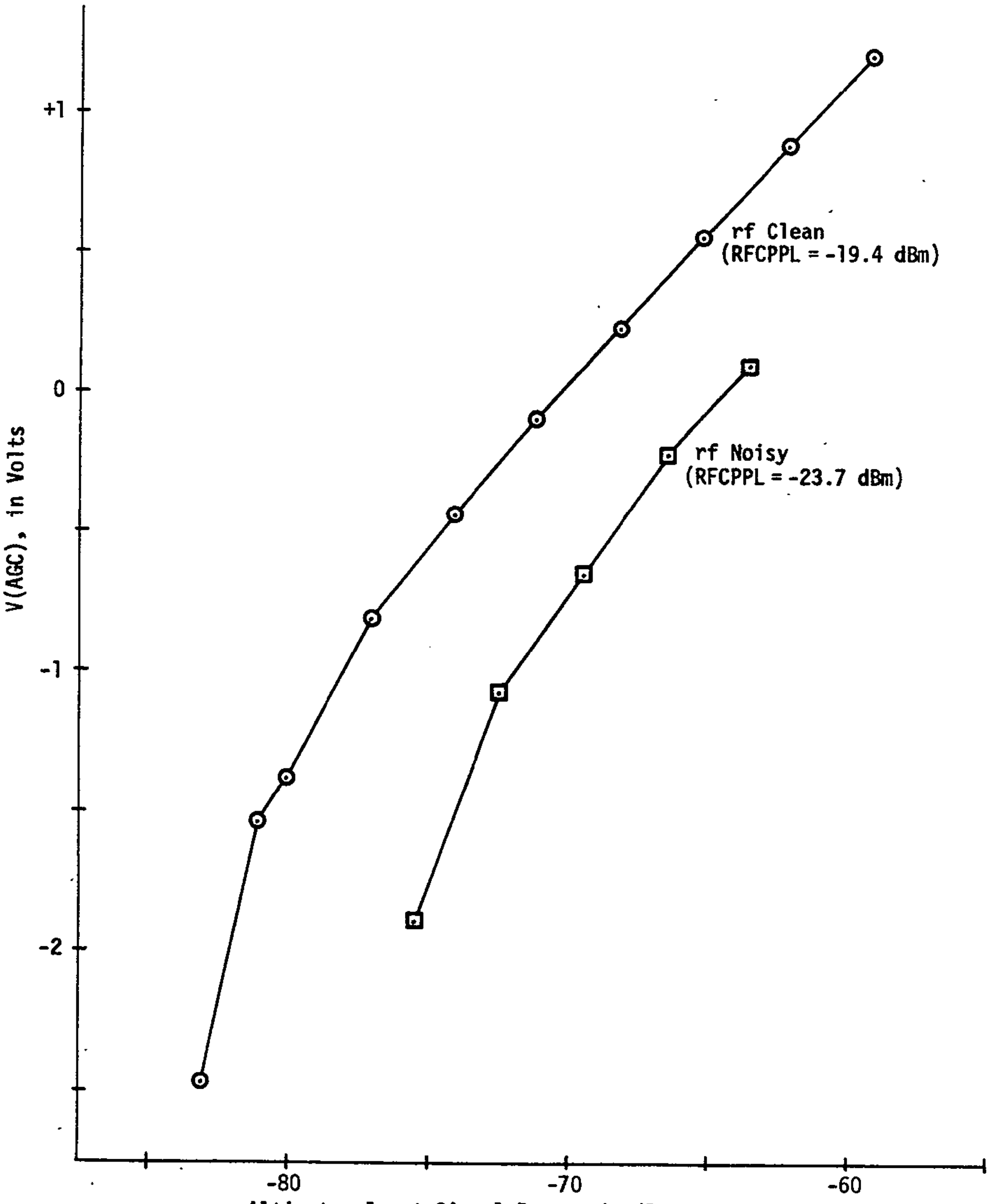
Signal Setup: As per EPTP Para. 9.3.1 except that RF/IF/STATISTICS = 16 dB.

Measured RFCPPL = -19.4 dBm

CCV + WGL = 39.8 dB

RF OUTPUT LEVEL ADJ.	Calibrated Test Input Signal Power	Received Signal V(AGC) in volts (mean of 10 readings)
0 dB	-59.2 dBm	+1.210 V
3	-62.2	0.885
6	-65.2	0.555
9	-68.2	0.230
12	-71.2	-0.097
15	-74.1	-0.443
18	-77.1	-0.814
21	-80.1	-1.379
22	-81.1	-1.539
24	-83.1	-2.468

Figure 4.4. V(AGC) vs. Input Power for Group C, Rectangular, Waveheight 0 Signals in Engineering Model Altimeter.



clean vs. clutter calibration question again appears because of the disagreement of these two curves.

These data should be viewed as preliminary results only and the principal importance of this exercise is in its help in defining the revised procedures which have been proposed for Protoflight Model further tests (and are included as an Appendix to this report).

4.2 AGC Test Results

4.2.1 General

The purpose of the Altimeter AGC test is to experimentally determine the AGC loop response over a range of receive power levels for both I-Mode and G-Mode. The following data are presented from a series of test performed on the Engineering Model altimeter. Test Waveforms used are the same as those described in Section 3.2.1 and 3.2.2. For these tests the Saicor CAPA was also used to compute the autocorrelation and probability density function of V(AGC). With this exception, the test set-up is the same as shown in Figure 3.1.

Unfortunately during this part of the test there was a power supply failure in the Engineering Model Altimeter so that no G-Mode and only a portion of the I-Mode tests were run. A summary of these results is given in Table 3.6.

An example correlation coefficient of V(AGC) for I-Mode standard waveform is given in Figure 4.5 to illustrate the typical AGC loop response. The corresponding PSD which was computed using the same technique described in the tracking loop test section of this report is shown in Figure 4.6. The PSD shows the closed loop AGC bandwidth to be on the order of 1 to 2 Hz. This compares favorably with the design AGC loop frequency response plot from [6] given in Figure 4.7.

A plot of I-Mode closed loop AGC bandwidth is given in Figure 4.8 for a range of receive powers. Note that a 15 dB change in receive power causes approximately a factor of 3 change in AGC bandwidth.

The I-Mode tracker AGC probability density functions taken during this test all appear to be very nearly Gaussian for all receive power levels. Figure 4.9 depicts a typical PDF computed using the Saicor CAPA and the standard I-Mode test waveform.

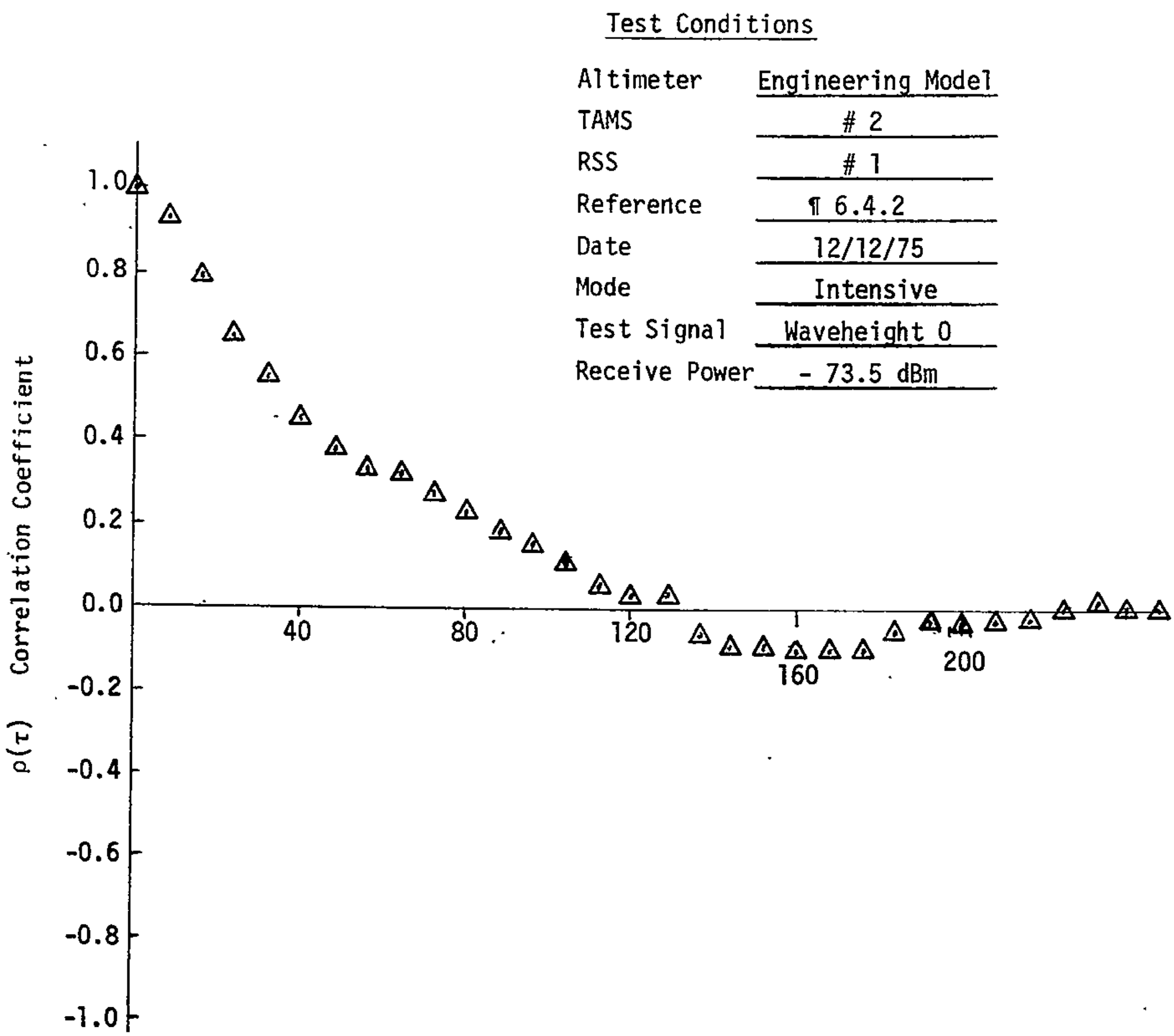


Figure 4.5. Measured Correlation Coefficient of AGC Voltage (Integer Multiples of Interpulse Period, T = 10.240 ns).

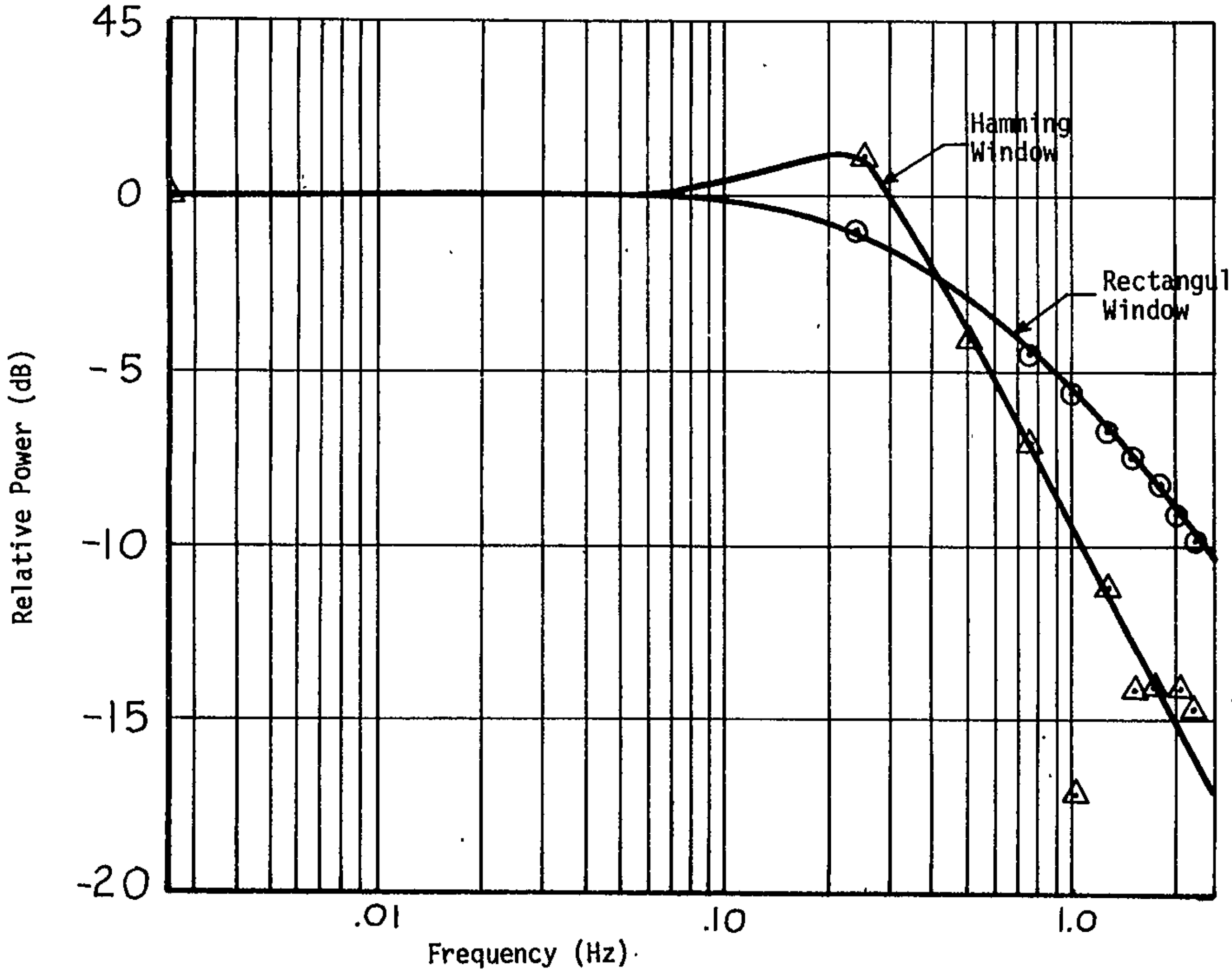


Figure 4.6. Power Spectral Density of AGC Loop Computed From Measured Correlation Coefficient Using 64-Point FFT. $P_r = -73.5$ dBm.

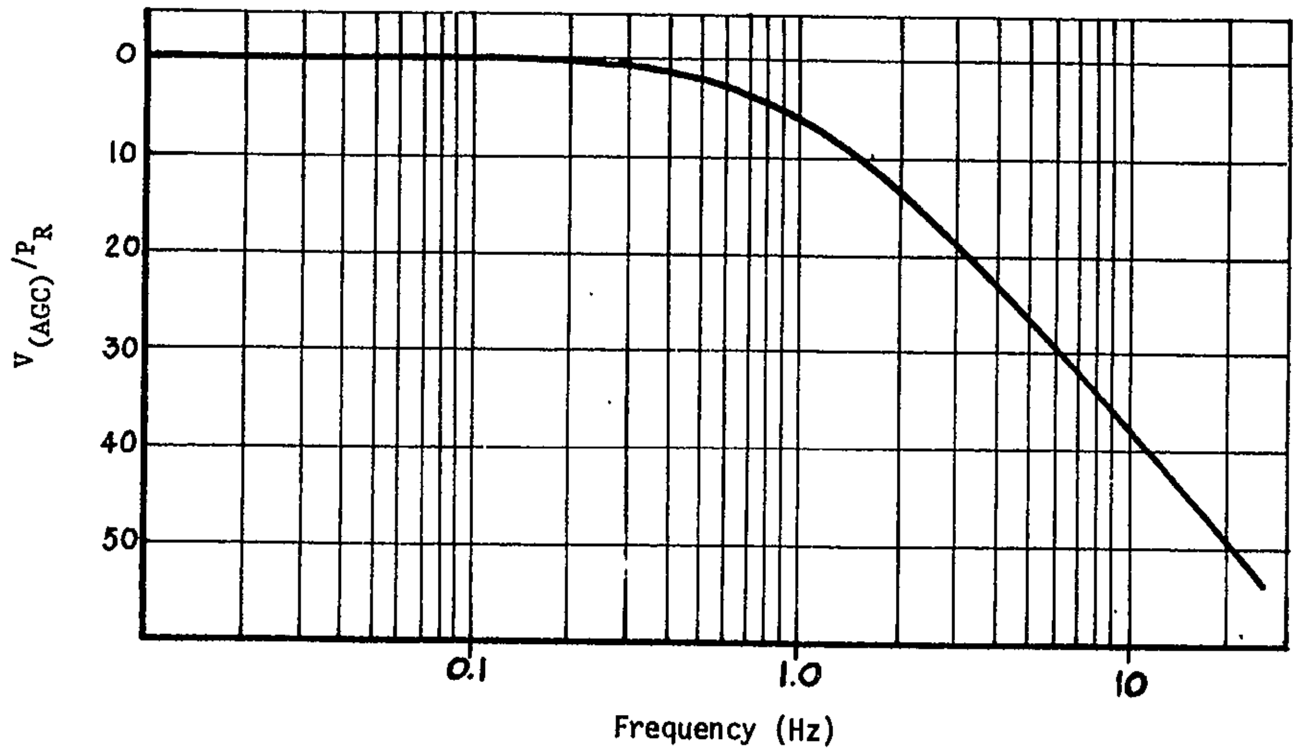


Figure 4.7. $V_{(AGC)}/P_R$ versus Frequency, from [6].

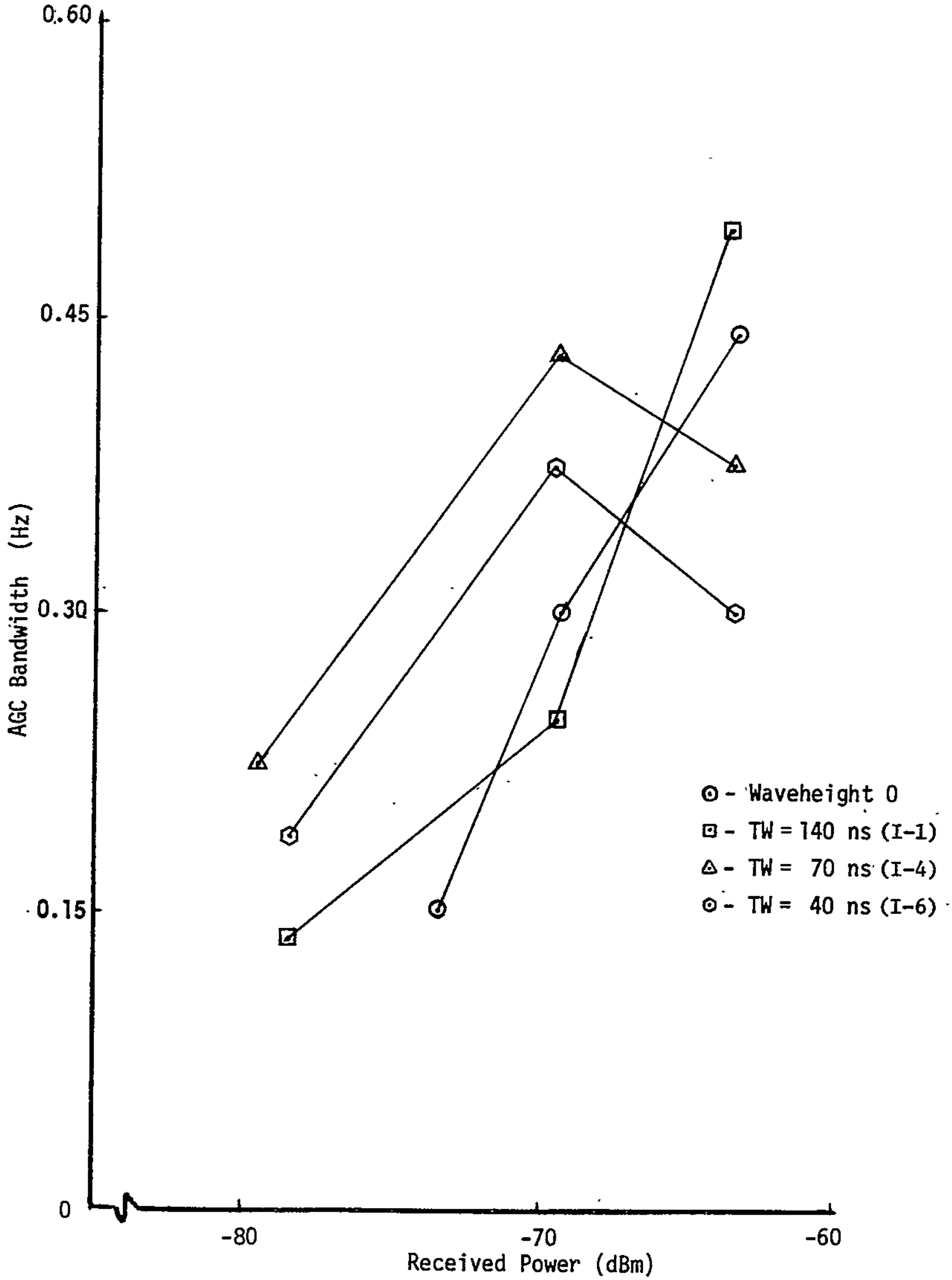


Figure 4.8. AGC Bandwidth Versus Altimeter Received Power.

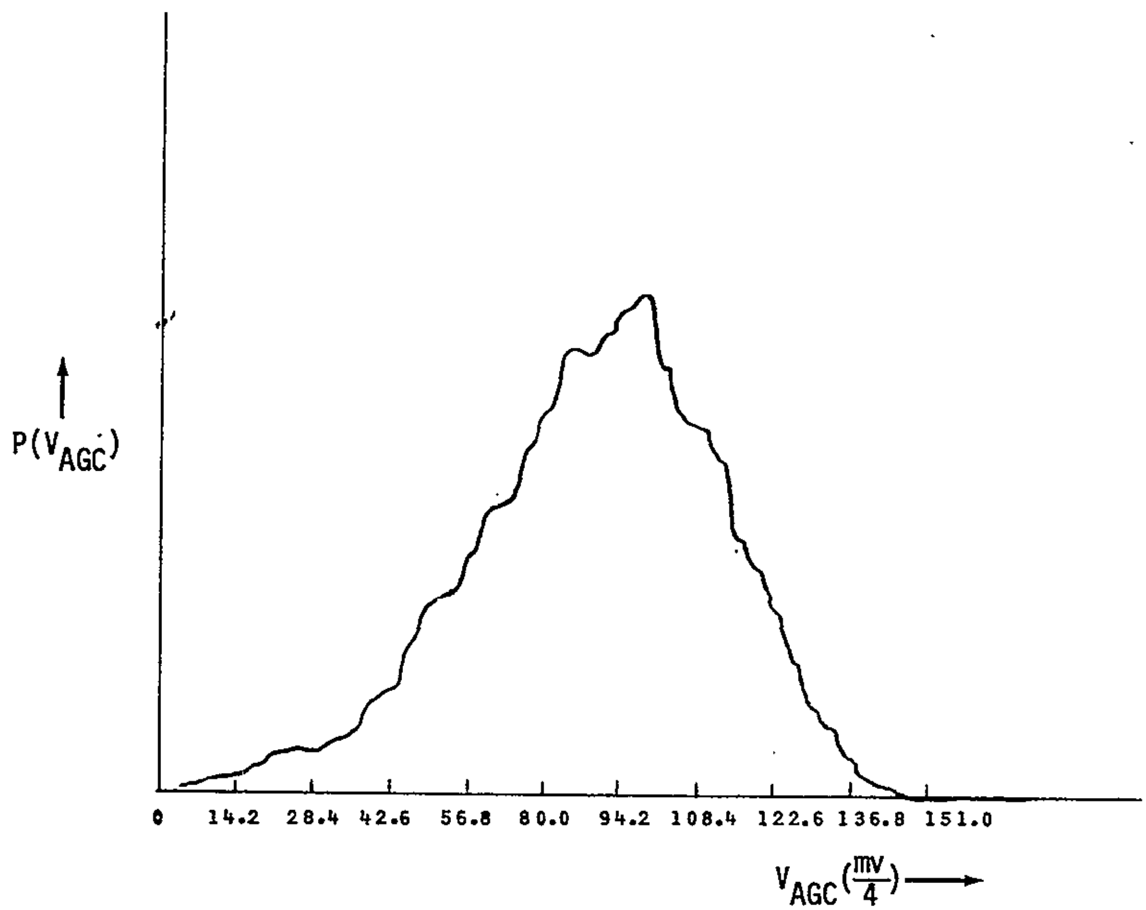


Figure 4.9. Typical I-Mode AGC Probability Density Function (PDF) for Waveheight 0 waveform and P_r = -69.5 dBm.

5.0 EMA WAVEFORM SAMPLER TESTS

5.1 Waveform Sampler Calibration

5.1.1 Standard Calibration

The waveform sampler calibration procedure of EPTP section 6.3.1 was accomplished to provide data for comparison with earlier tests at GE. While a detailed comparison has not yet been carried out, it is clear that at least waveform sample-and-hold gate number 4 has changed in behavior since the GE testing, and these calibration results in this section should be used instead of the earlier GE results for interpretation of the waveform sampler measurements in other portions of the Engineering Model current testing.

Tables 5.1 through 5.4 and the corresponding Figures 5.1 through 5.16 summarize the measured V_{out} versus V_{in} (the Engineering Units vs. Functional Units) average waveform samplers 1 through 16, GE designation IAW1 through IAW16. These tables and figures include measurements at the EPTP-specified V_{in} values -.20, -.10,0.0,+.10,.30,.40,.50, and +.60 volts. Additional measurements were obtained for V_{in} values of -.15, .05, and +.05, and +.15 volts. Operator error in the testing led to erroneous results for V_{in} = +0.20 volts, and the +0.20 volt V_{in} points in these Tables and Figures were instead obtained by linear extrapolation of the +0.10 and +0.15 volt points. It is felt on the basis of the near-linearity of the curves for $V_{in} < +0.30$ volts that this is an acceptable temporary fix for the error discovered during analysis of the results; however, at least the +0.10, 0.15, 0.20, and 0.25 volt V_{in} measurements should be repeated the next time there is access to the correctly operating Engineering Model altimeter.

The procedure above, from EPTP 6.3.1, also obtained data for the 16 instantaneous waveform samplers IAW1-16 and the I-Mode averaging gates V(N), V(A/S), V(R), and V(P), the noise attitude/specular, ramp, and plateau gates respectively. Data for IAW1-16 have not been reduced as yet, and the four averaging gates are presented in Section 6.

5.2 Waveform Sampler Response to Trapezoidal Signal

As a first effort at assessing the presence (or absence) of different S&H responses to positive-going and to negative-going signals, the EPTP

(Text continued on page 89.)

Table 5.1 . Calibration Results for IAW 2,4,6,8.

Data obtained 11/13/75 for Engineering Model Altimeter, I-Mode, by Procedure Detailed in EPTP Para. 6.3.1

Ambient Test Environment	TT1	TT2	TT3	TT4	TT5	TT6
Start-of-Procedure Temperatures	28.8°C	32.4	34.4	40.7	39.8	30.8
End-of-Procedure Temperatures	32.9	38.5	41.2	48.2	47.0	37.6°C

V_{in}, volts (Functional Units)	V_{out}, volts (Engineering Units) for Indicated Quantity			
	IAW 2	IAW 4	IAW 6	IAW 8
-0.20	-3.388	-3.854	-3.485	-3.623
-0.15	-2.183	-3.353	-2.278	-2.263
-0.10	-1.464	-2.750	-1.573	-1.520
-0.05	-0.685	-2.123	-0.800	-0.724
0	+0.075	-1.572	-0.055	+0.038
0.05	0.816	-1.126	+0.678	0.785
0.10	1.579	-0.920	1.434	1.551
0.15	2.348	-0.868	2.205	2.326
0.20†	3.117	-0.816	2.976	3.101
0.30	4.532	-0.759	4.394	4.481
0.40	4.998	-0.739	4.998	4.958
0.50	4.998	-0.748	4.998	4.934
0.60	4.998	-0.852	4.998	4.805

†The V_{out} values for .20 volt V_{in} were obtained from linear extrapolation of the .10 and .15 volt V_{in} results instead of from direct measurement.

Table 5.2. Calibration Results for IAW 10, 12, 14, 16

Data obtained 11/13/75 for Engineering Model Altimeter, I-Mode, by Procedure Detailed in EPTP Para. 6.3.1

Ambient Test Environment	TT1	TT2	TT3	TT4	TT5	TT6
Start-of-Procedure Temperatures	28.8°C	32.4	34.4	40.7	39.8	30.8
End-of-Procedure Temperatures	32.9	38.5	41.2	48.2	47.0	37.6°C

V_{in}, volts (Functional Units)	V_{out}, volts (Engineering Units) for Indicated Quantity			
	IAW 10	IAW 12	IAW 14	IAW 16
-0.20	-3.686	-3.539	-3.370	-3.569
-0.15	-2.168	-2.160	-1.997	-2.236
-0.10	-1.402	-1.410	-1.271	-1.496
-0.05	-0.602	-0.605	-0.484	-0.696
0	+0.161	+0.168	+0.266	+0.070
0.05	0.909	0.921	1.007	0.820
0.10	1.680	1.695	1.764	1.590
0.15	2.455	2.469	2.525	2.360
0.20†	3.230	3.243	3.286	3.130
0.30	4.624	4.626	4.622	4.508
0.40	4.954	4.998	4.998	4.998
0.50	4.951	4.998	4.998	4.998
0.60	4.879	4.879	4.998	4.998

†The V_{out} values for .20 volt V_{in} were obtained from linear extrapolation of the .10 and .15 volt V_{in} results instead of from direct measurement.

Table 5.3. Calibration Results for IAW 1, 3, 5, 7.

Data obtained 11/13/75 for Engineering Model Altimeter, I-Mode, by Procedure Detailed in EPTP Para. 6.3.1

Ambient Test Environment	TT1	TT2	TT3	TT4	TT5	TT6
Start-of-Procedure Temperatures	28.8°C	32.4	34.4	40.7	39.8	30.8
End-of-Procedure Temperatures	32.9	38.5	41.2	48.2	47.0	37.6°C

V_{in}, volts (Functional Units)	V_{out}, volts (Engineering Units) for Indicated Quantity			
	IAW 1	IAW 3	IAW 5	IAW 7
-0.20	-3.225	-2.937	-3.243	-3.216
-0.15	-2.300	-2.248	-2.276	-2.309
-0.10	-1.565	-1.539	-1.589	-1.573
-0.05	-0.771	-0.725	-0.810	-0.777
0	-0.001	+0.045	-0.057	-0.018
0.05	+0.748	0.897	+0.683	+0.728
0.10	1.522	1.567	1.440	1.487
0.15	2.303	2.343	2.208	2.247
0.20†	3.084	3.119	2.976	3.007
0.30	3.767	3.325	4.375	4.408
0.40	3.773	3.450	4.998	4.979
0.50	3.774	3.441	4.998	4.980
0.60	3.739	3.497	4.973	4.979

†The V_{out} values for .20 volt V_{in} were obtained from linear extrapolation of the .10 and .15 volt V_{in} results instead of from direct measurement.

Table 5.4. Calibration Results for IAW 9, 11, 13, 15.

Data obtained 11/13/75 for Engineering Model Altimeter, I-Mode, by Procedure Detailed in EPTP Para. 6.3.1

Ambient Test Environment	TT1	TT2	TT3	TT4	TT5	TT6
Start-of-Procedure Temperatures	28.8°C	32.4	34.4	40.7	39.8	30.8
End-of-Procedure Temperatures	32.9	38.5	41.2	48.2	47.0	37.6°C

V_{in}, volts (Functional Units)	V_{out}, volts (Engineering Units) for Indicated Quantity			
	IAW 9	IAW 11	IAW 13	IAW 15
-0.20	-3.193	-3.182	-3.172	-3.197
-0.15	-2.242	-2.239	-2.205	-2.247
-0.10	-1.502	-1.468	-1.504	-1.521
-0.05	-0.695	-0.646	-0.710	-0.726
0	+0.069	+0.123	+0.054	+0.025
0.05	0.825	0.879	0.802	0.768
0.10	1.596	1.646	1.560	1.518
0.15	2.375	2.420	2.332	2.288
0.20†	3.154	3.194	3.104	3.058
0.30	4.588	4.578	4.523	4.193
0.40	4.998	4.855	4.998	4.355
0.50	4.998	4.830	4.998	4.387
0.60	4.998	4.726	4.998	4.227

†The V_{out} values for .20 volt V_{in} were obtained from linear extrapolation of the .10 and .15 volt V_{in} results instead of from direct measurement.

Figure 5.1. Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 1, IAW1.

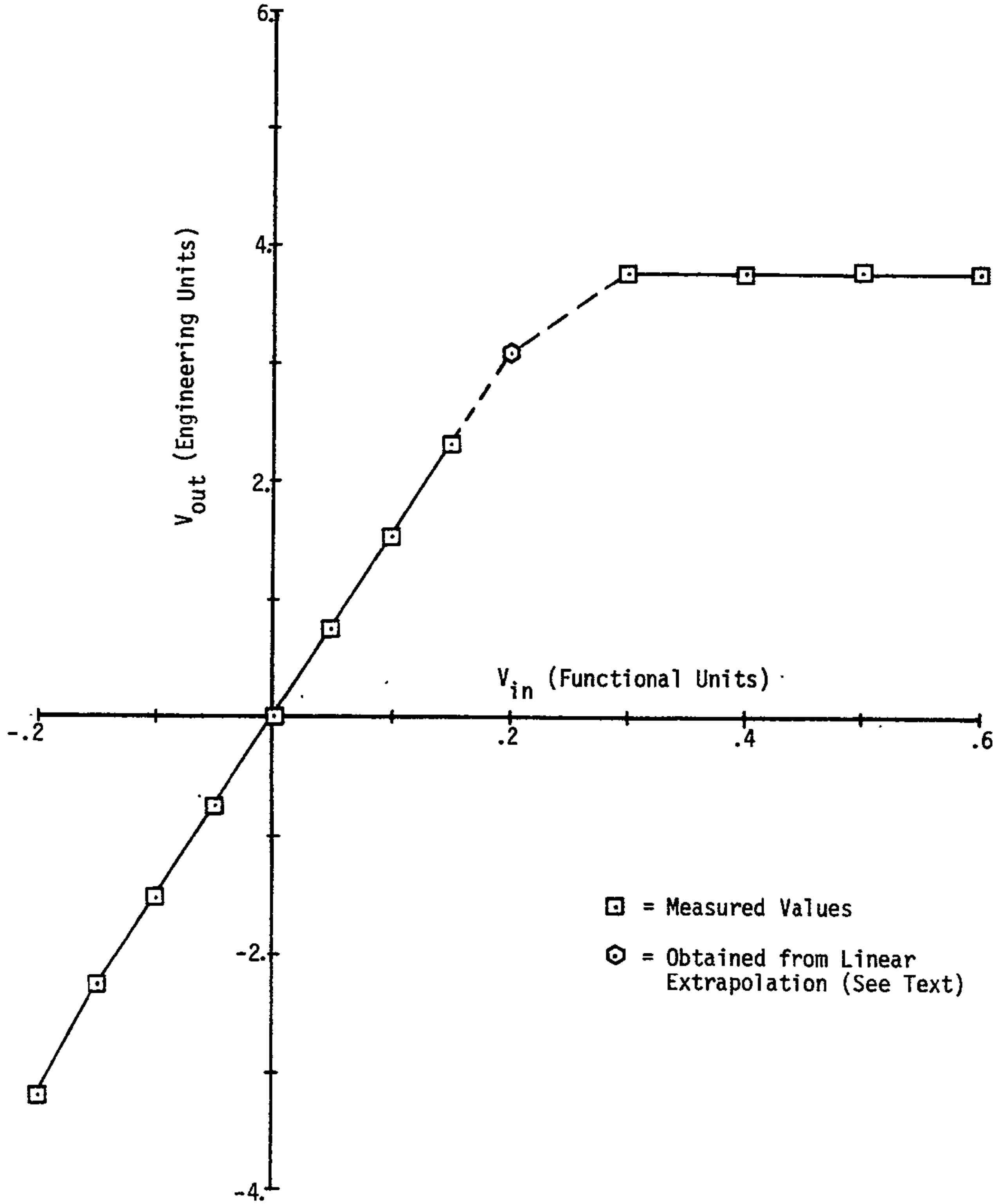


Figure 5.2. Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 2, IAW2.

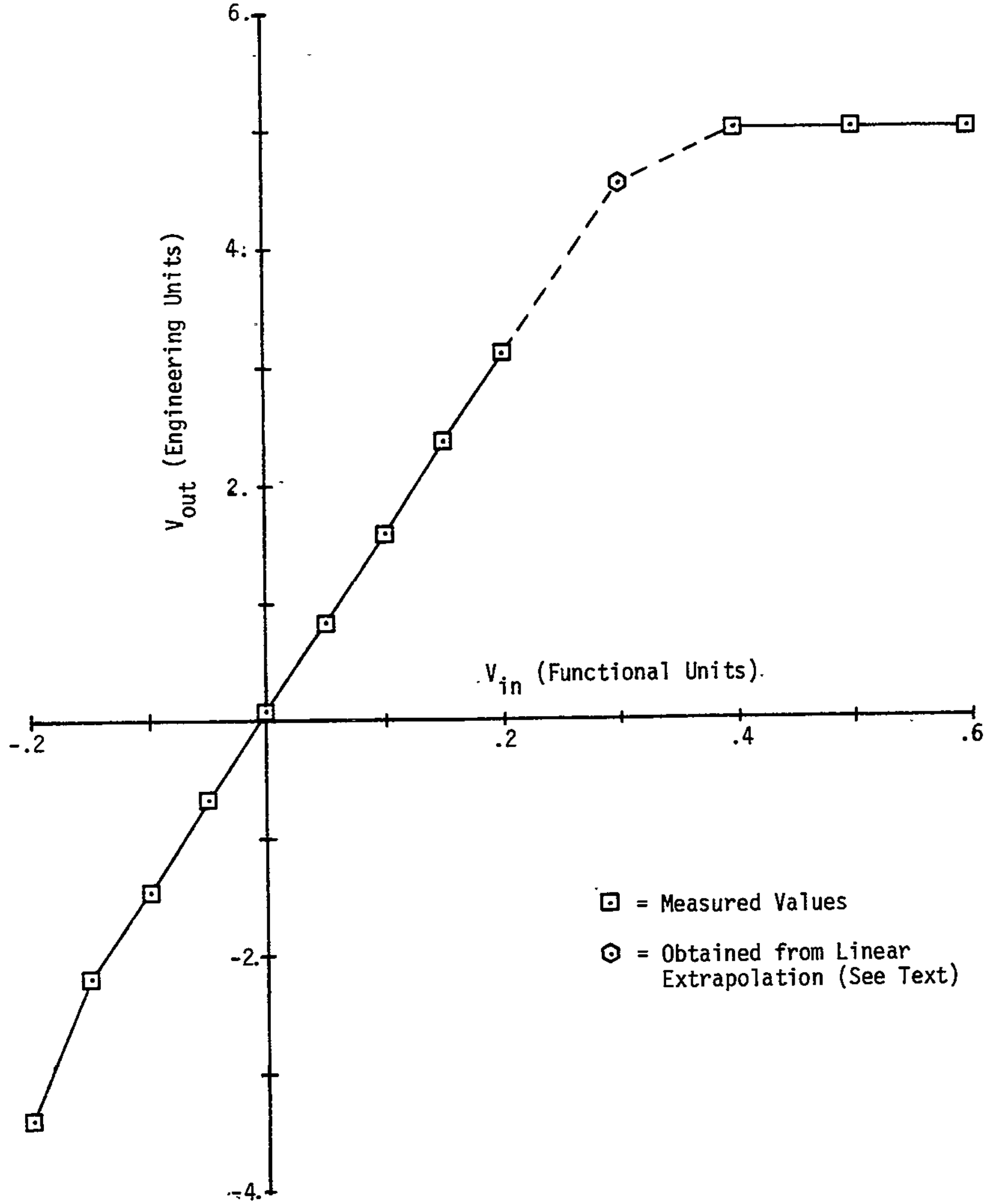


Figure 5.3. Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 3, IAW3.

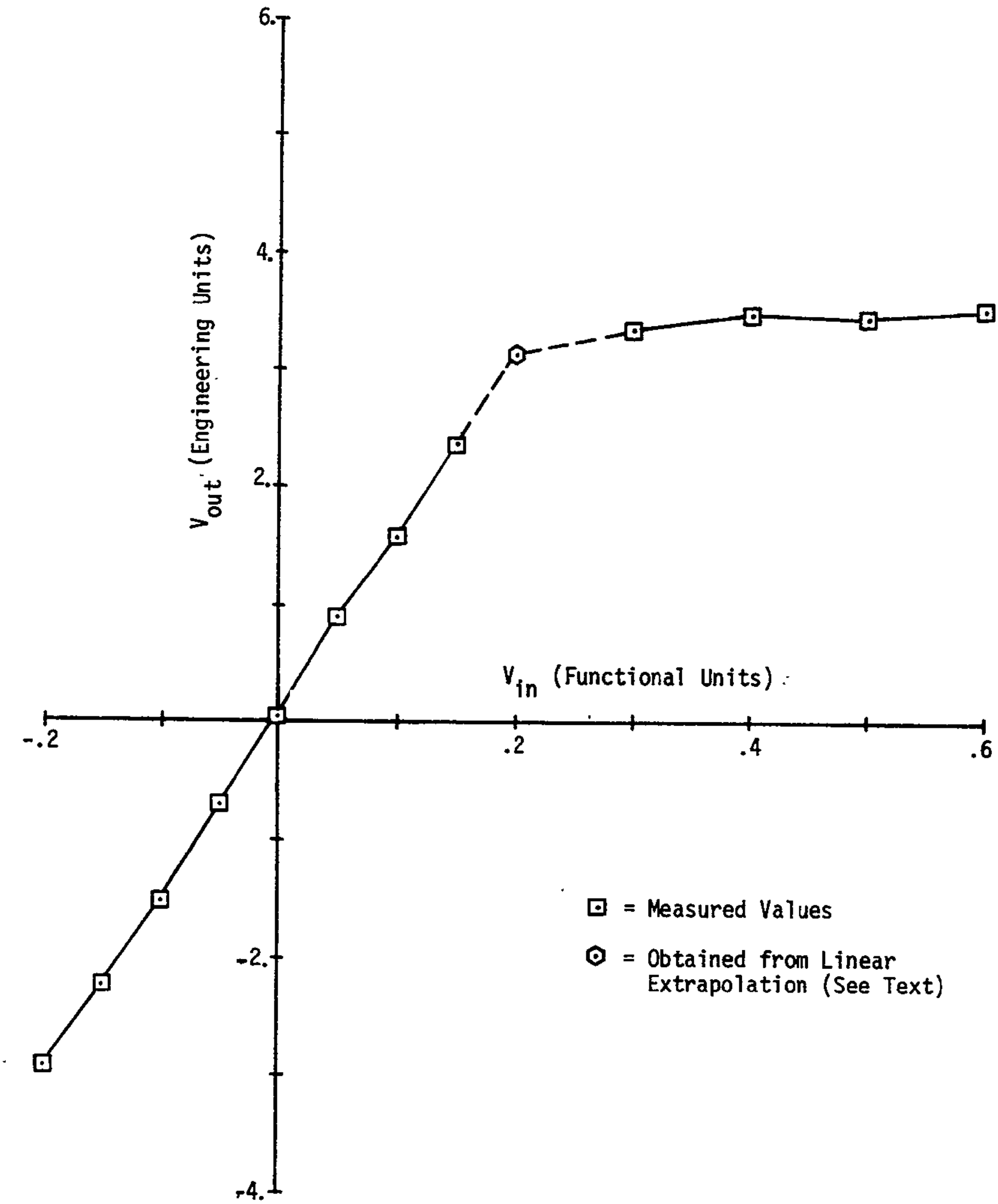


Figure 5.4. Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 4, IAW4.

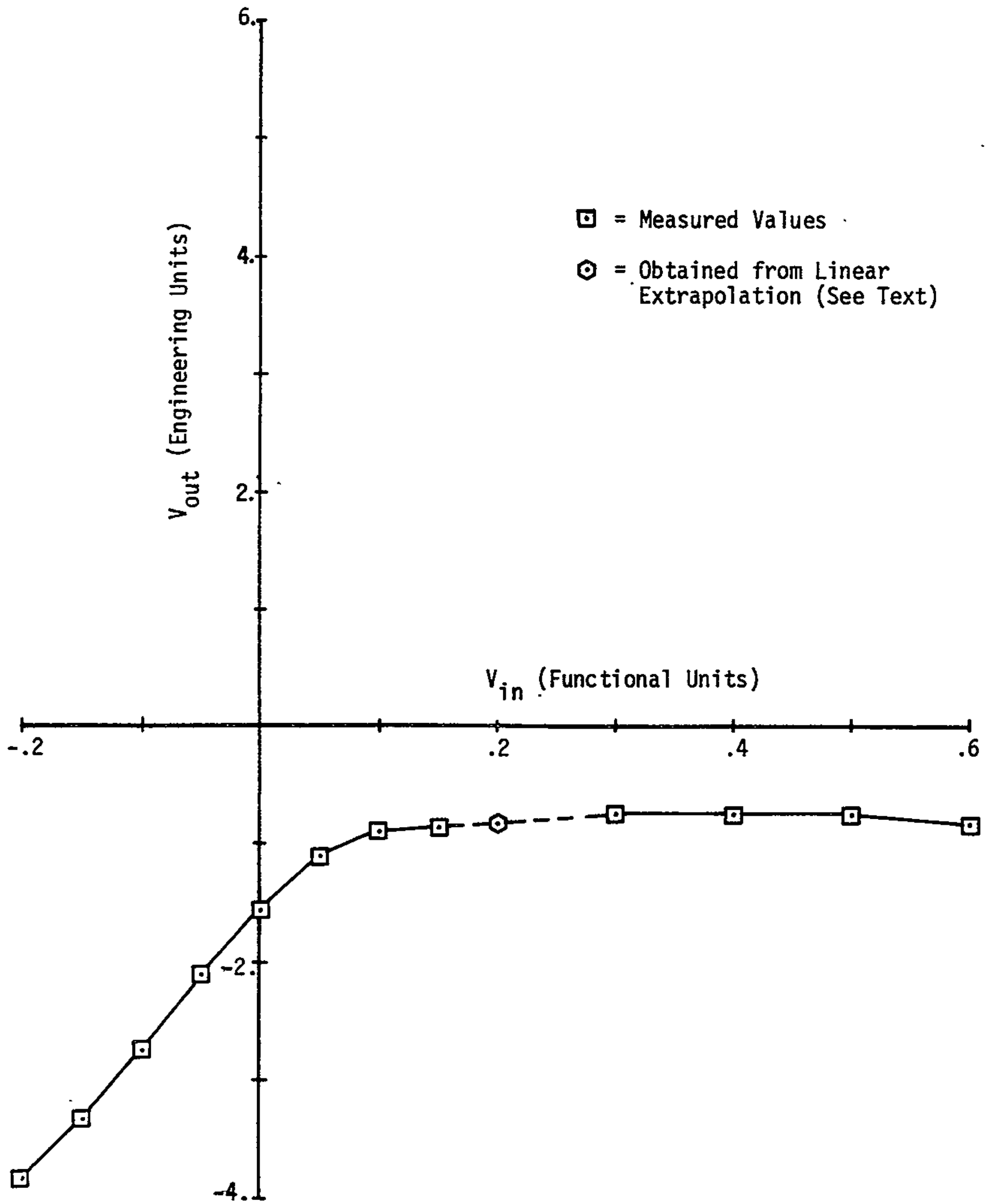


Figure 5.5 . Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 5, IAW5.

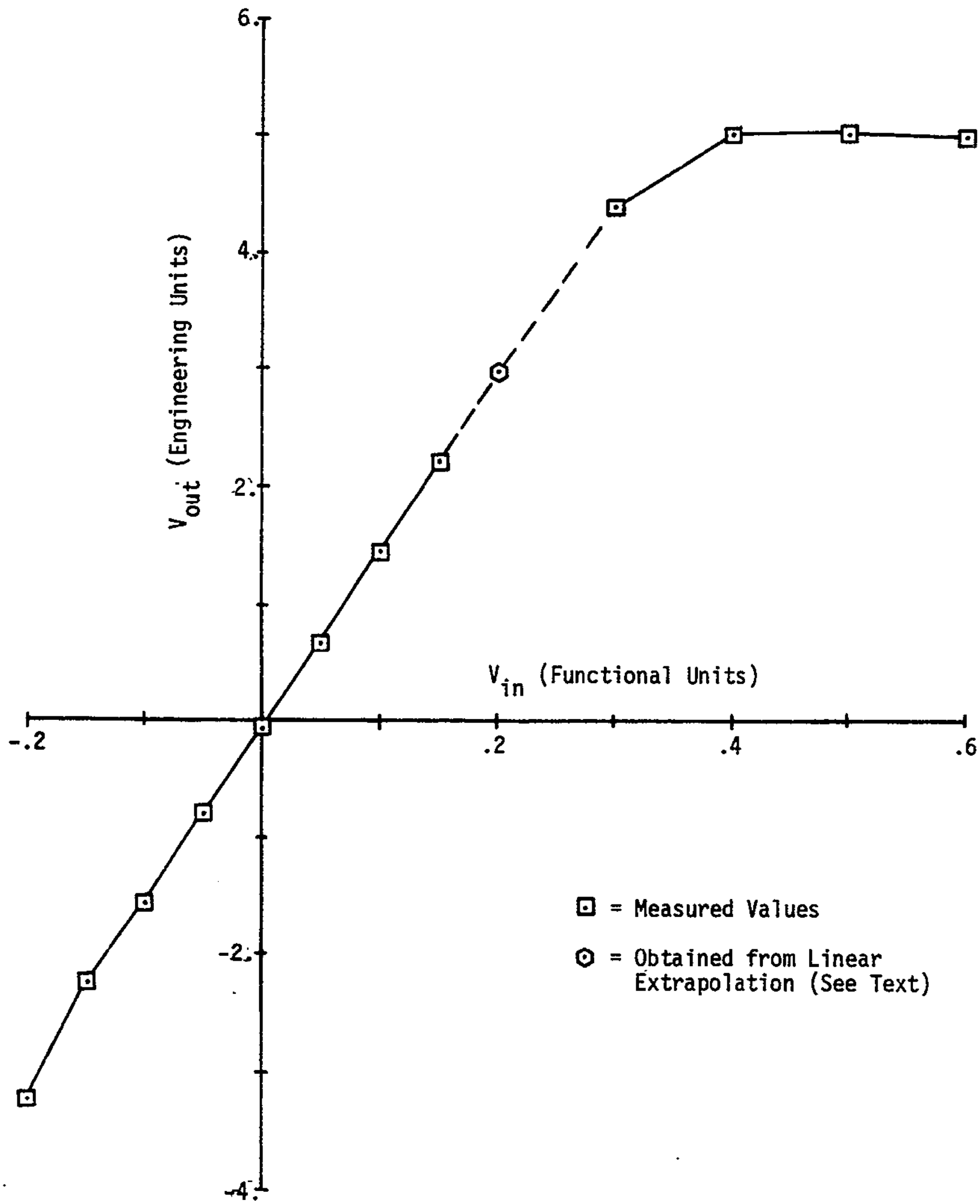


Figure 5.6 . Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 6, IAW6.

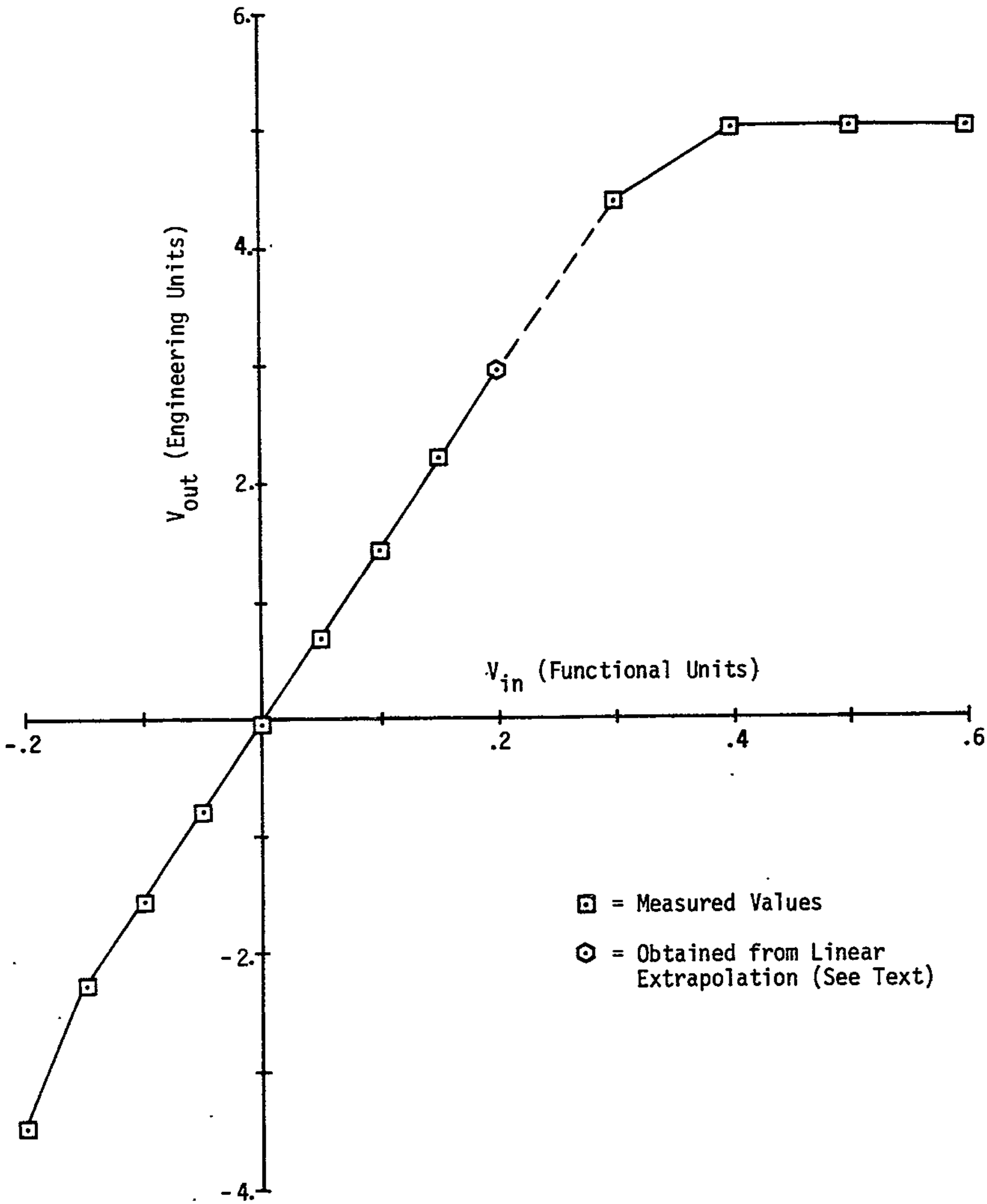


Figure 5.7. Engineering Model 11/13/75 Calibration Date for Average Waveform Sampler No. 7, IAW7.

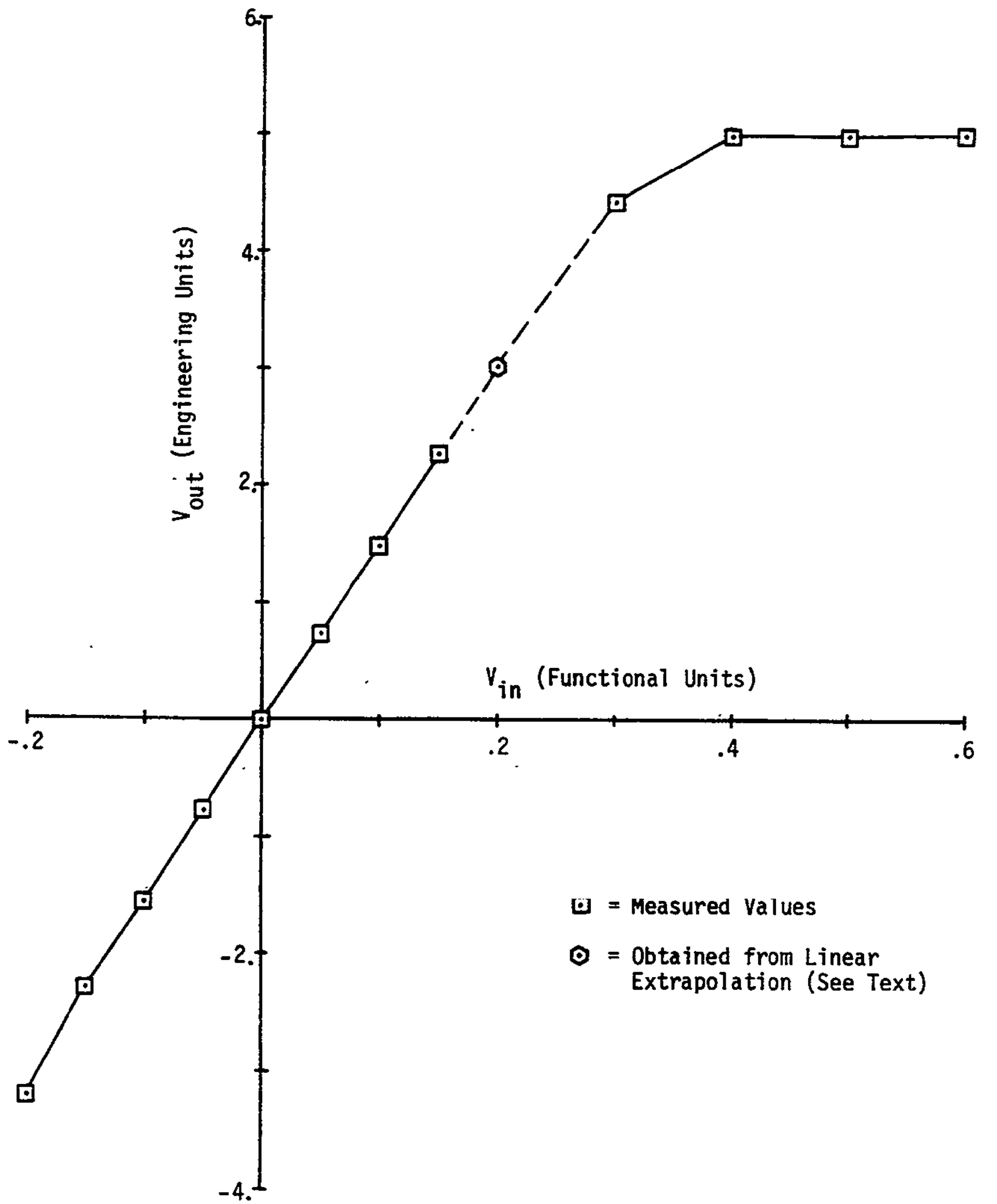


Figure 5.8. Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 8, IAW8.

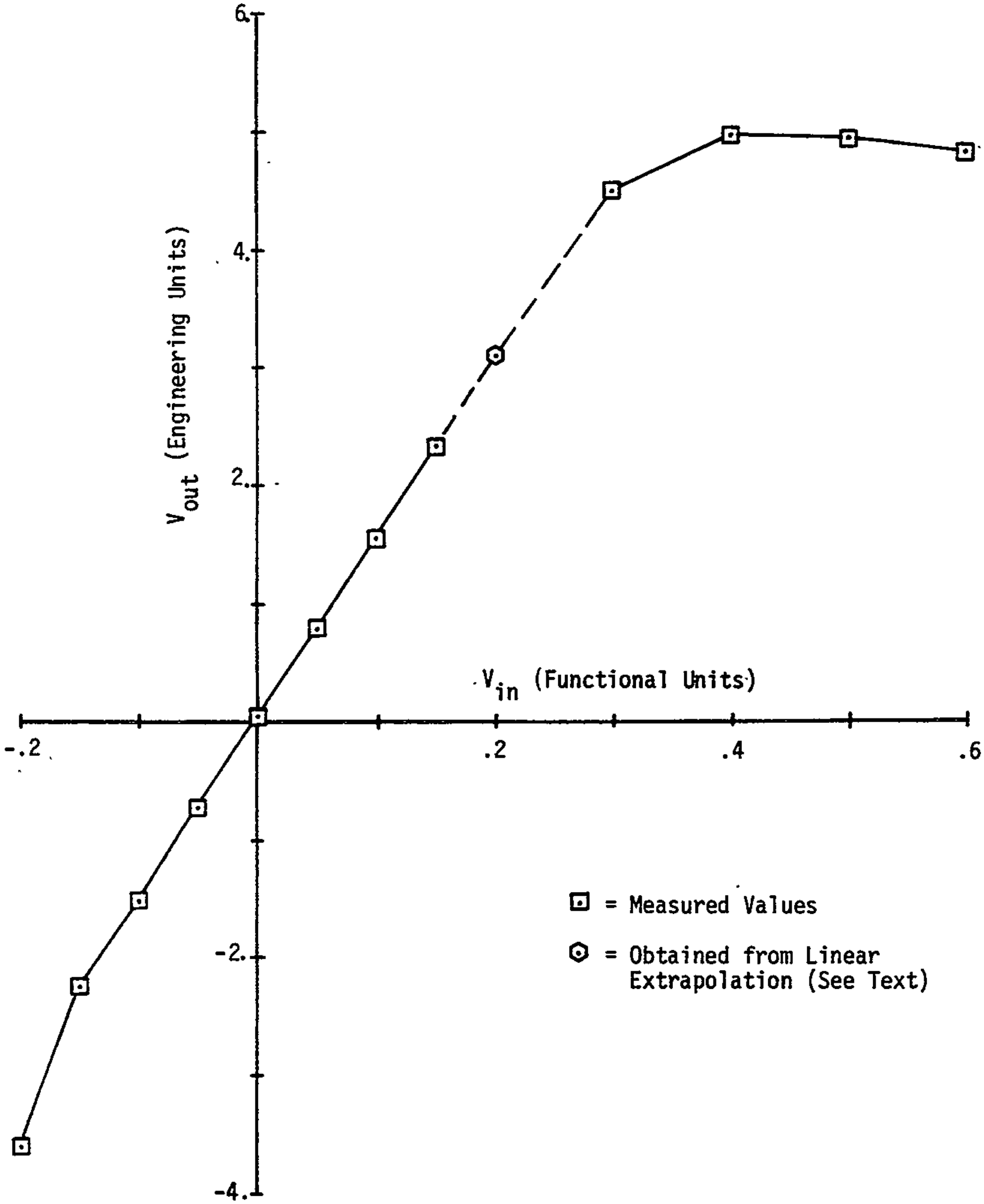


Figure 5.9. Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 9, IAW9.

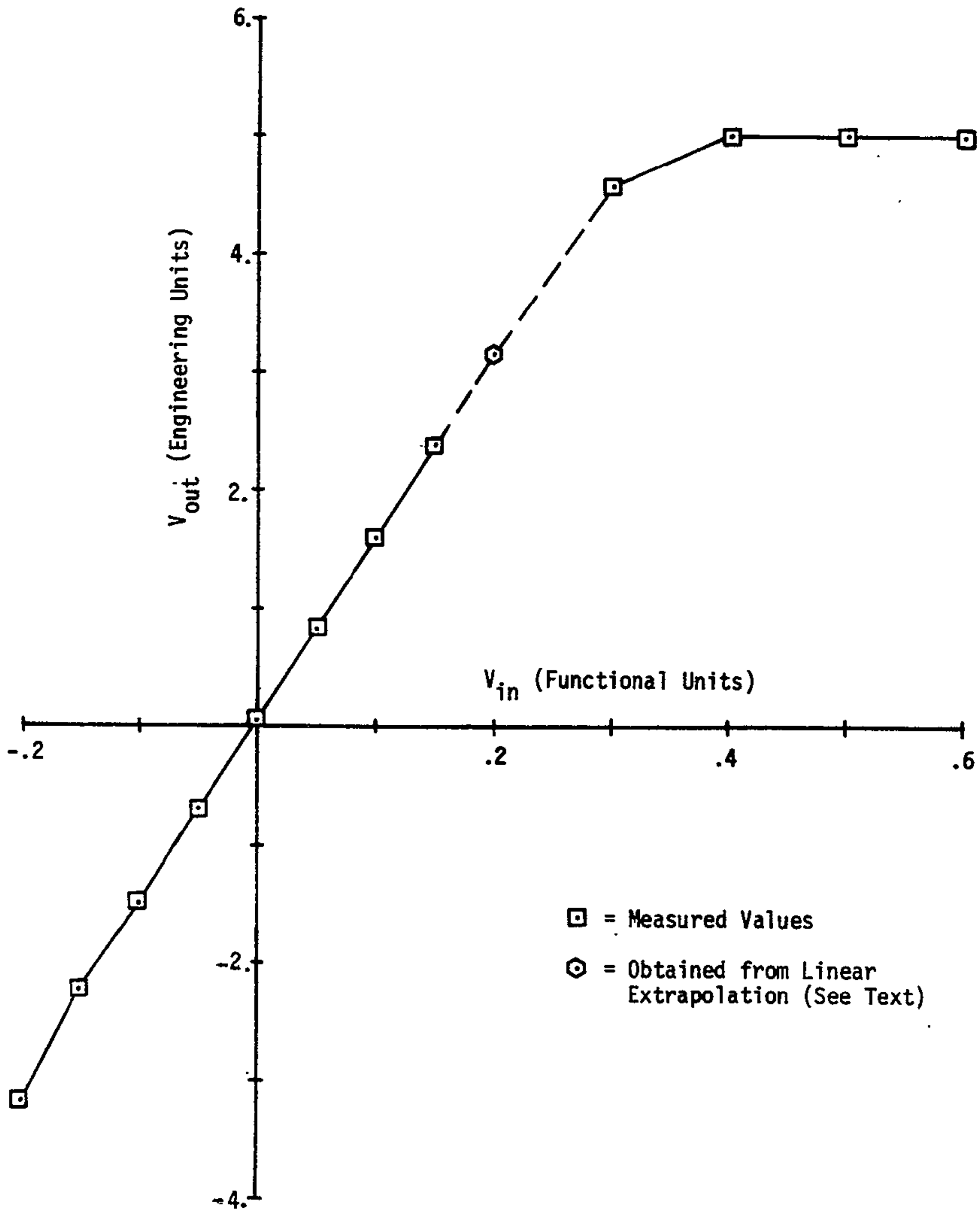


Figure 5.10. Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 10, IAW10.

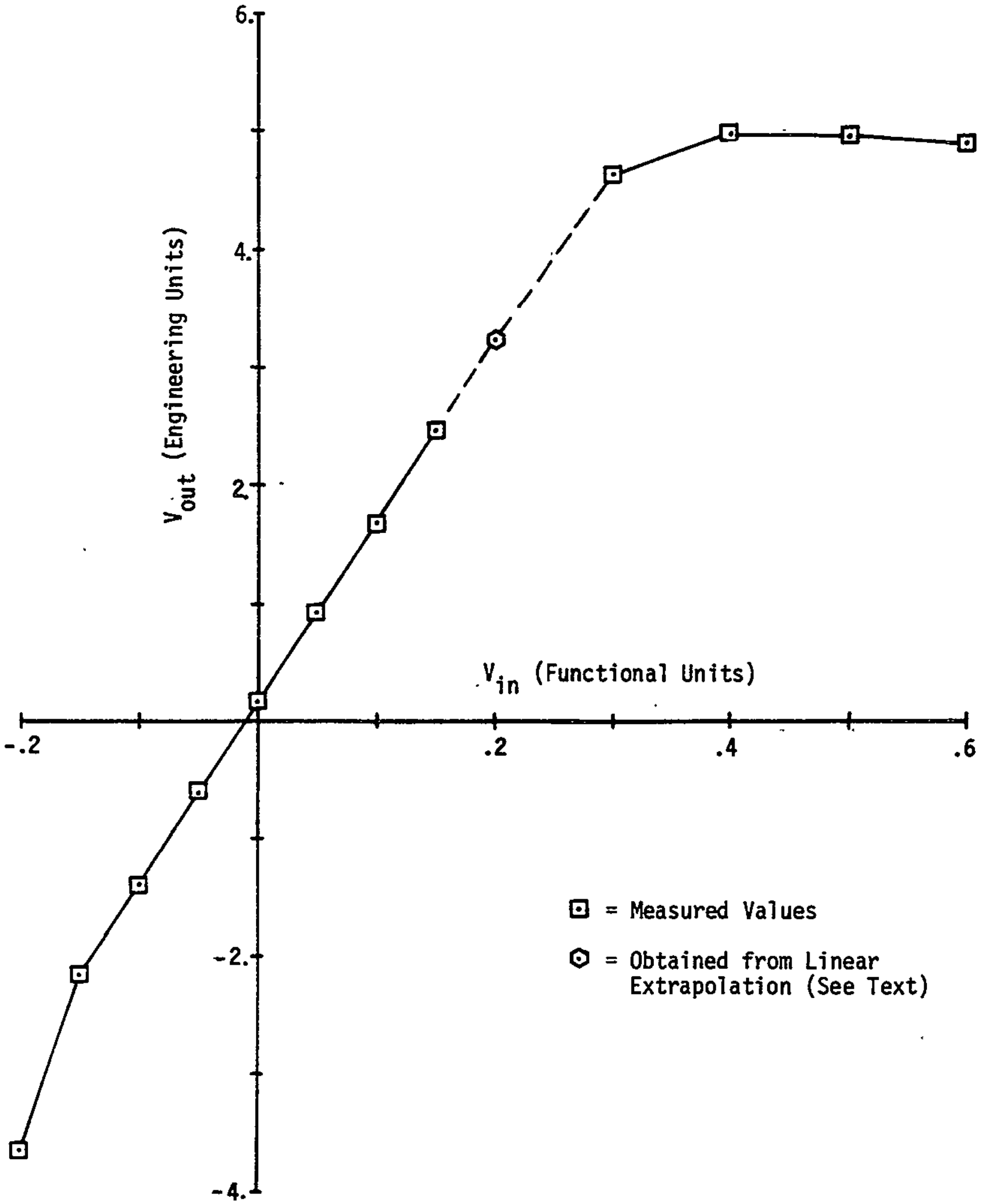


Figure 5.11. Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 11, IAW11.

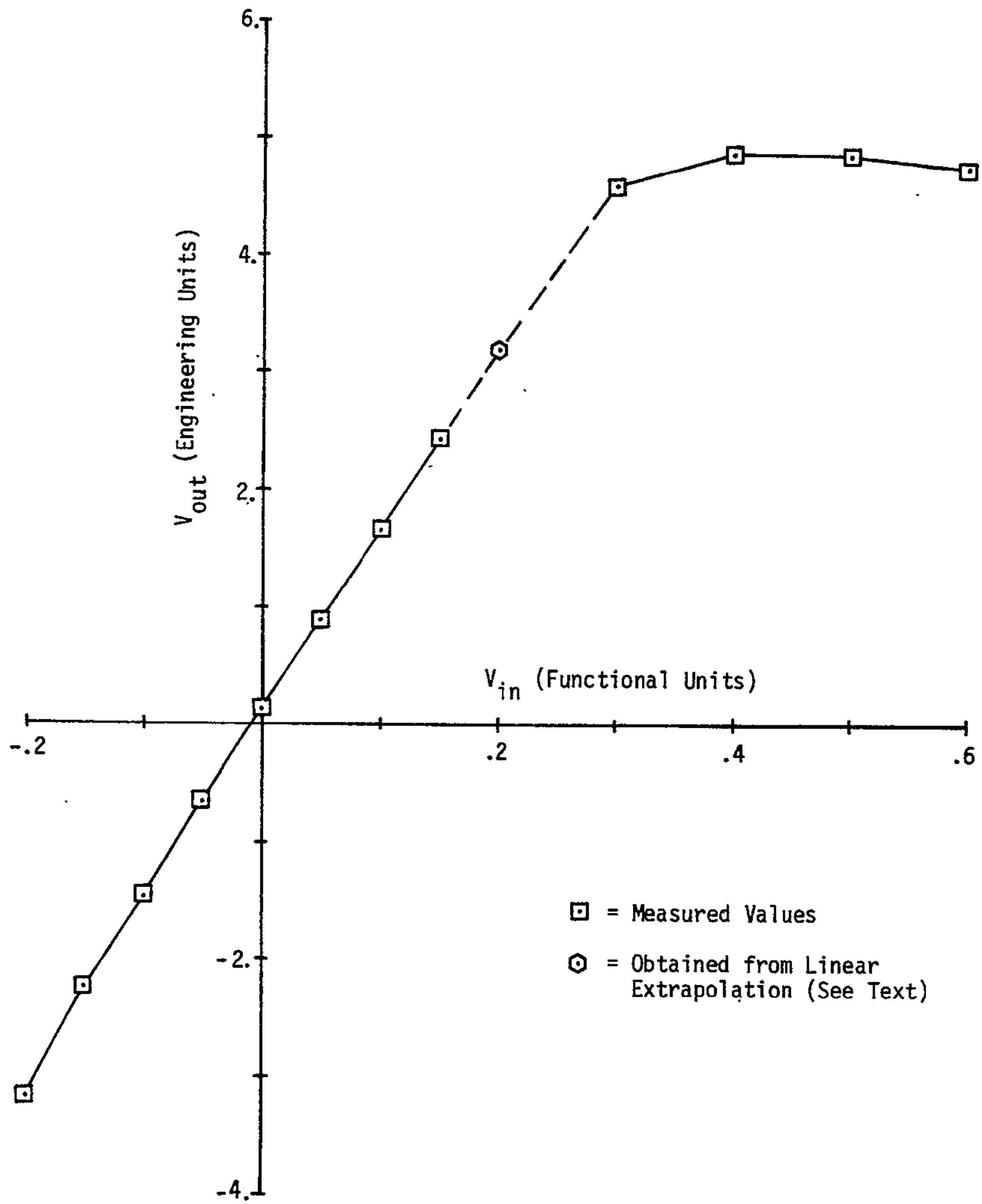


Figure 5.12. Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 12, IAW12.

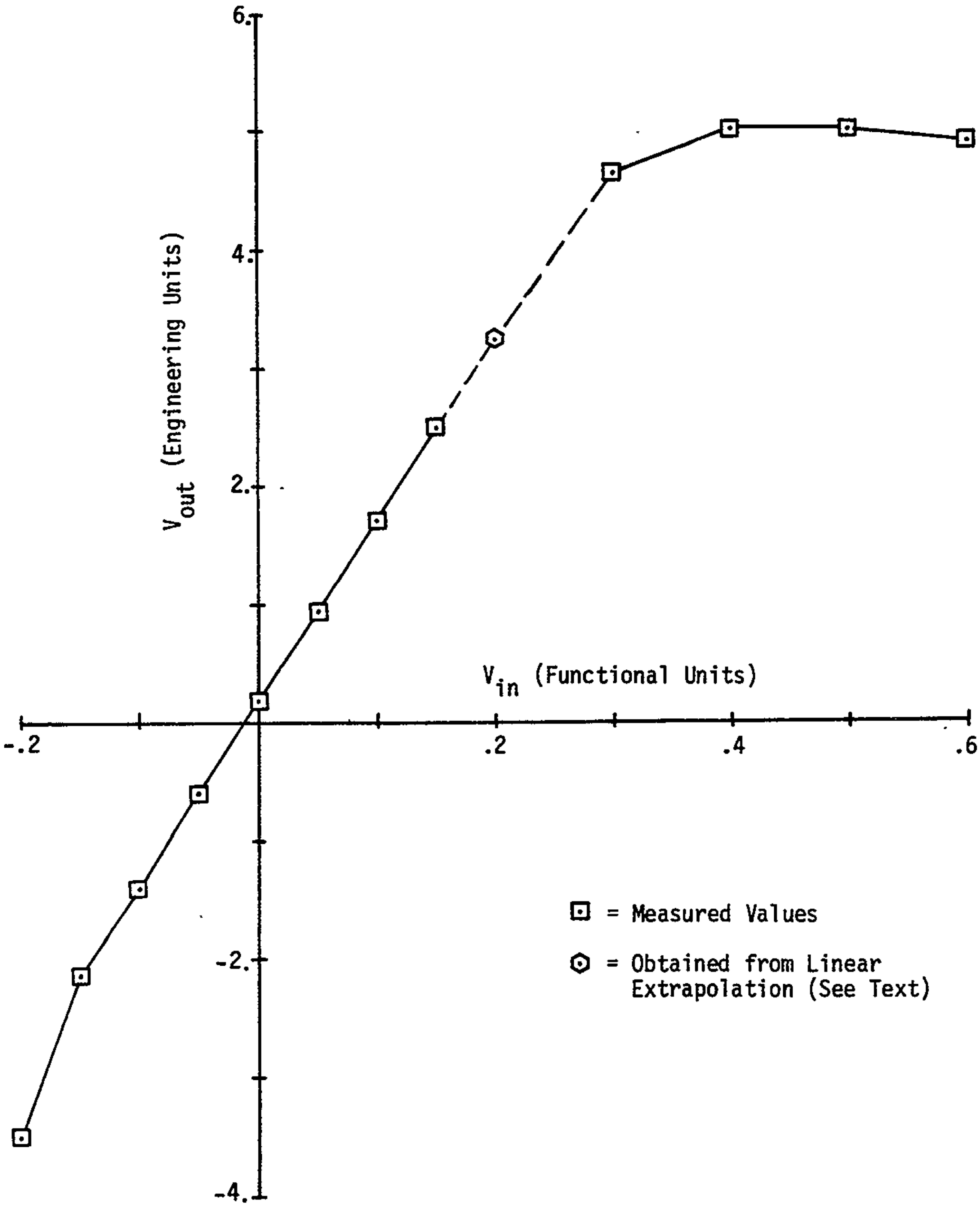


Figure 5.13. Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 13, IAW13.

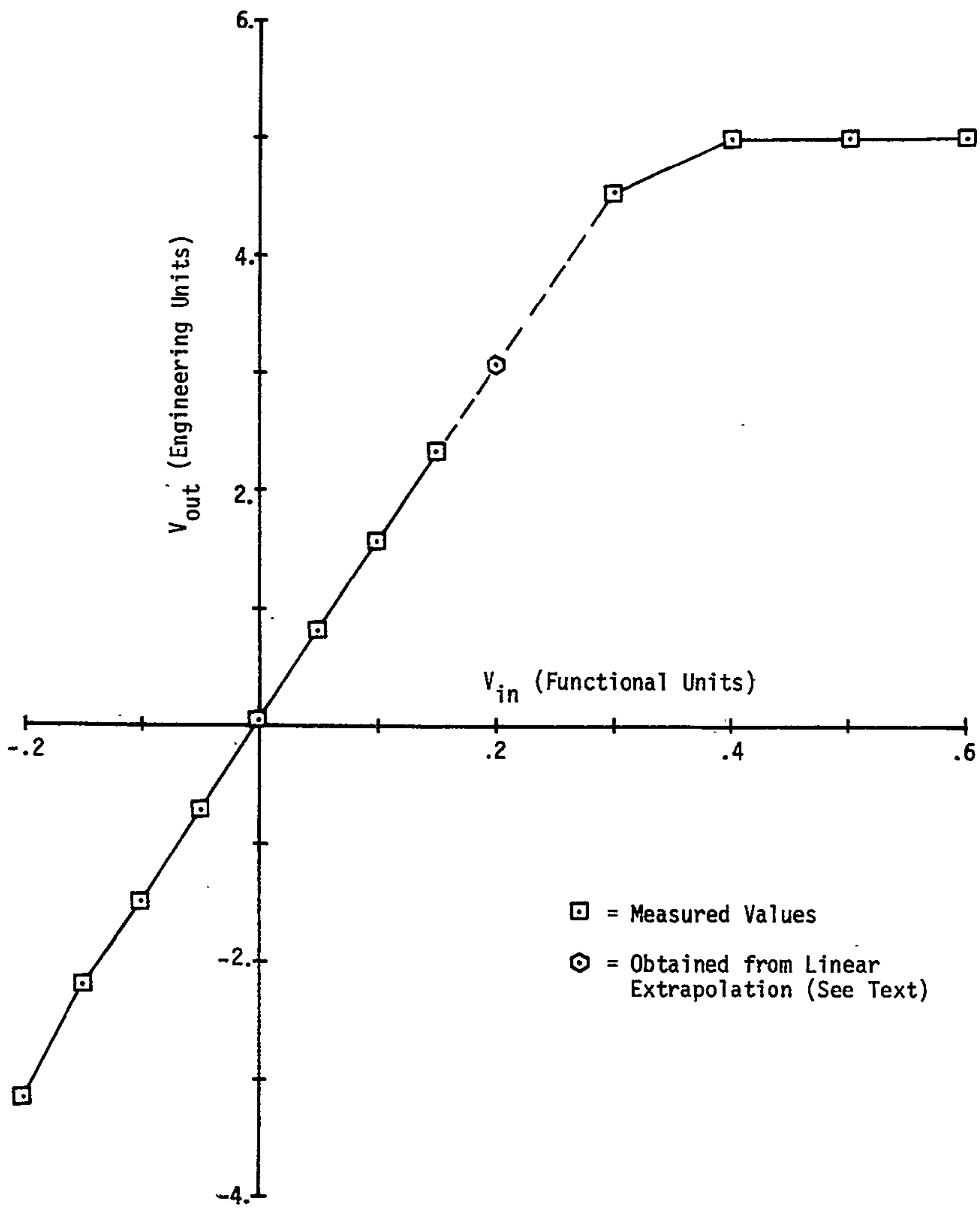


Figure 5.14. Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 14, IAW14.

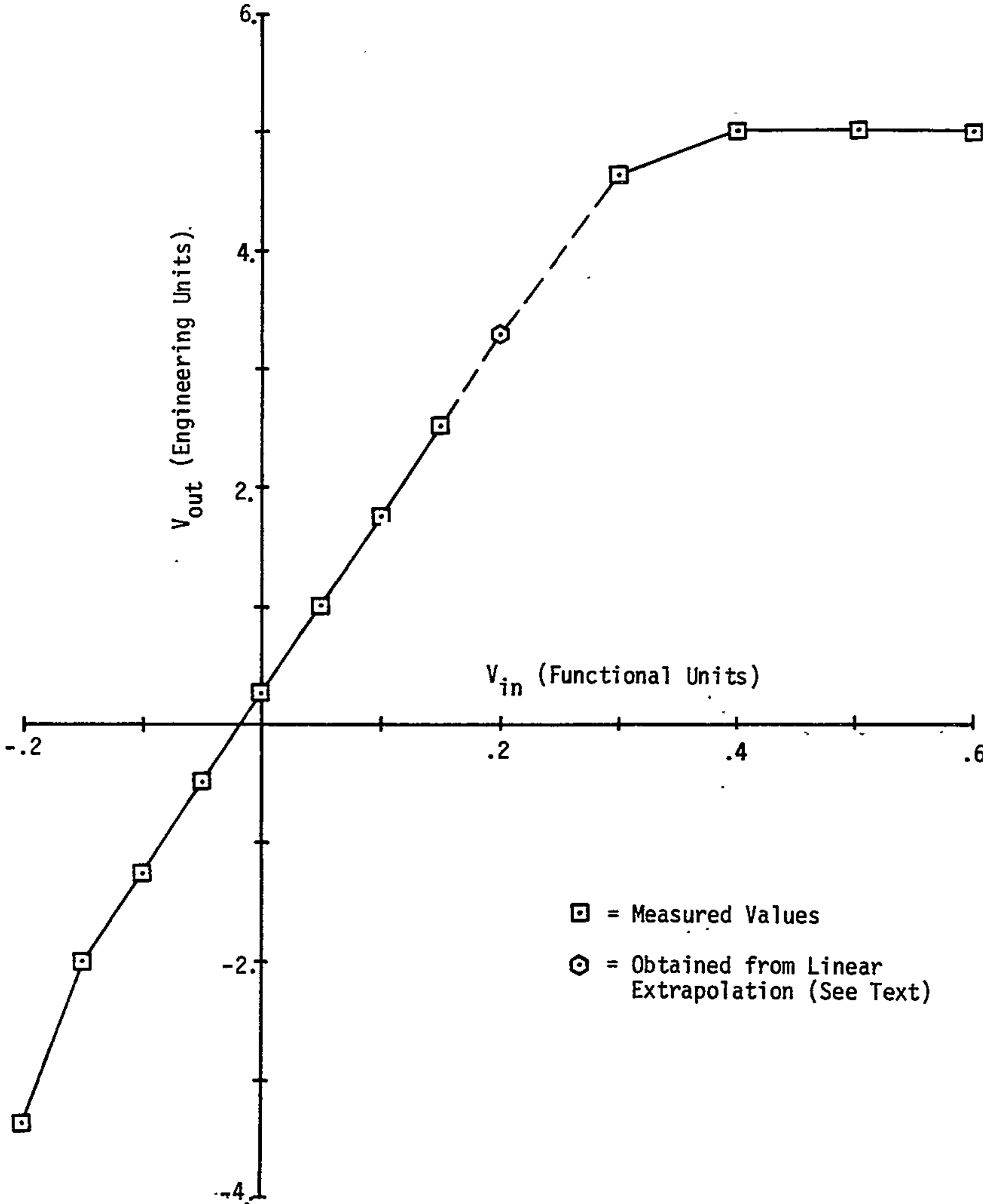


Figure 5.15. Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 15, IAW15.

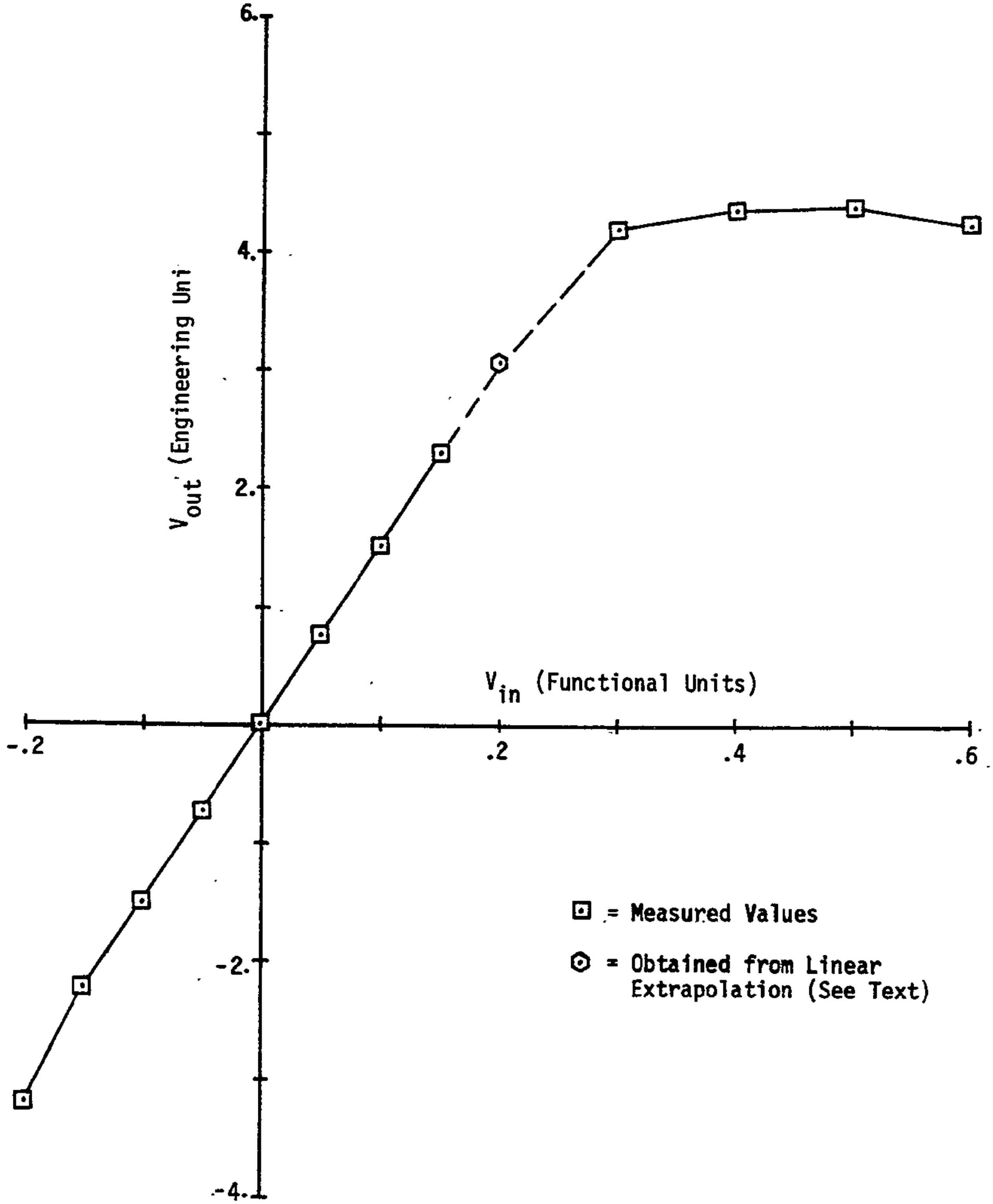
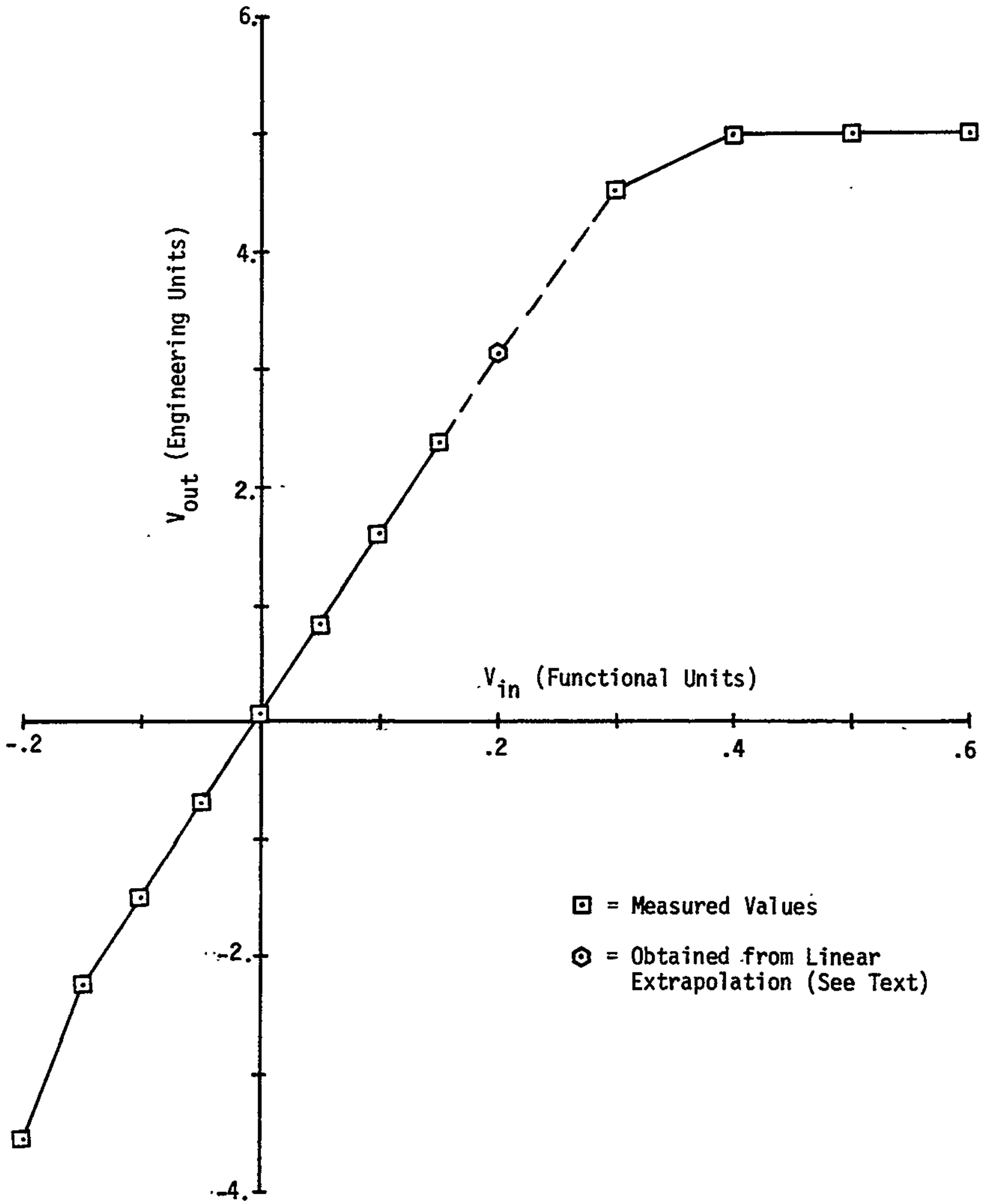


Figure 5.16. Engineering Model 11/13/75 Calibration Data for Average Waveform Sampler No. 16, IAW16.



Paragraph 6.3.1.5 procedure was carried out with a non-standard video input signal. Specifically, the video input signal injected into the Engineering Model's receiver at the TAMS REST ACCESS panel was a trapezoid with a linear ramp rise time of 40 nanoseconds, a +0.20 plateau of 20 ns duration, and a linear ramp back to the zero baseline with again a ramp length of 40 ns.

These pulse specifications are obtained directly from the oscilloscope display of the pulse from the TAMS EH Pulse Generator, and so are good only to 5-10% for this first try at this procedure.

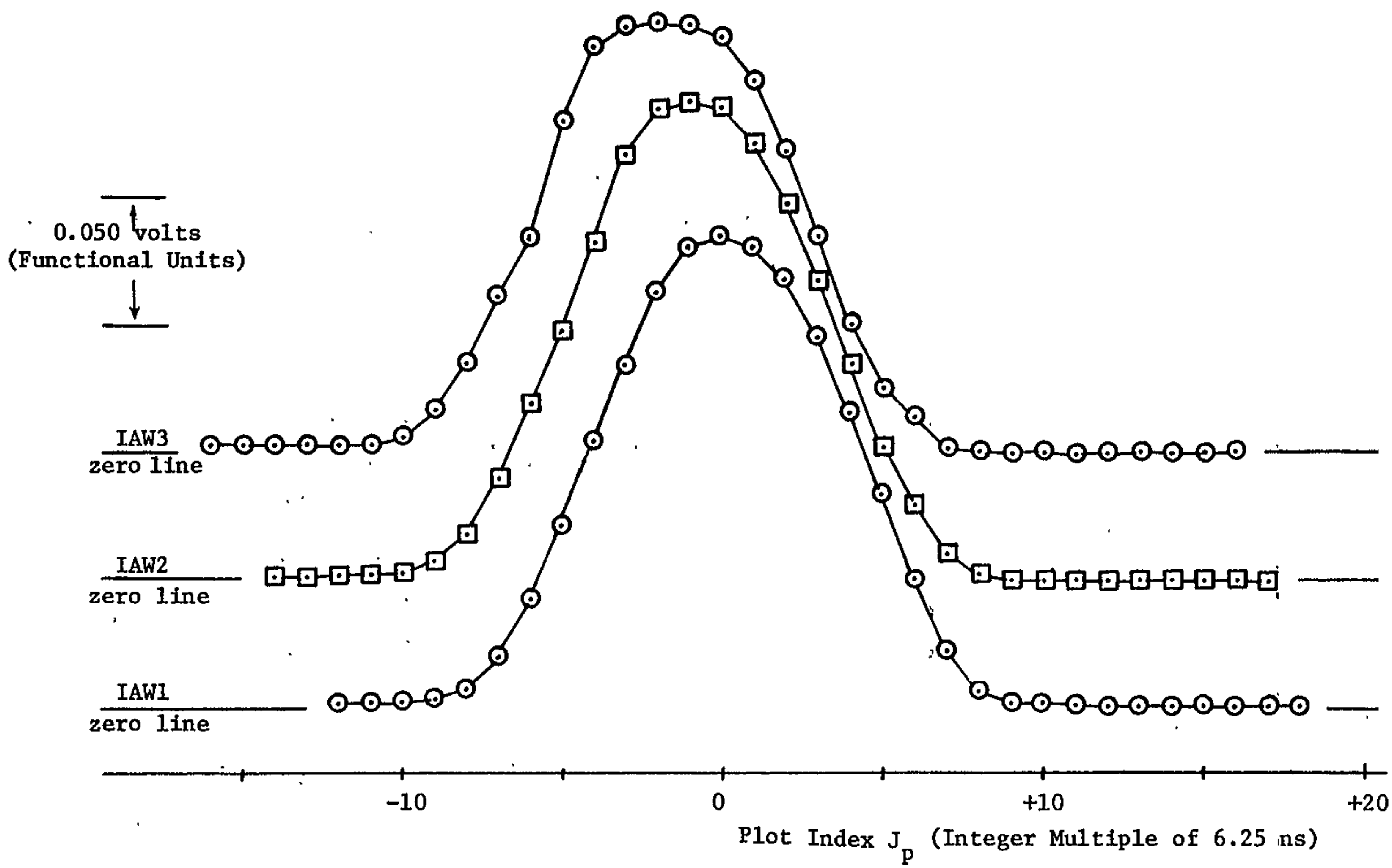
This trapezoidal pulse was moved through the set of waveform samplers in 6.25 ns increments by incrementing the TAMS DDG setting; 6.25 ns is the least significant bit value for the TAMS DDG. At each DDG setting, three sets of printout values were obtained for ASSP2 and another three for ASSP3 by using the 32 CHANNEL A/D TEST program in the TAMS computer.

The first DDG setting was 3334140 and the DDG Thumbwheel switches were decremented down to 3334106; then the DDG setting of 3334152 was used and the DDG setting subsequently decremented down to 3334140, the same value as at the start of the procedure. Thus the three sets of ASSP2 and ASSP3 printout values were obtained twice, at the start and at the finish of the process, while at all other DDG settings only one set of three each ASSP2 and ASSP3 values were acquired.

The results from this procedure are converted to Functional Units by use of the calibration curves of Figures 5.1 through 5.16. When these results are displayed as a function of the DDG setting, the trapezoidal pulse will be seen as recovered by the waveform samplers. The correct relative timing or relative positioning of the individual S&H gates can be seen as well, and Figure 5.17 shows this by a plot of average S&H gates 1-3, IAW1-3, versus TAMS DDG setting. A constant has been subtracted from the (octal) DDG setting and the result converted to a decimal number for convenience; the three S&H gate results have also been separated vertically on Figure 5.17 for ease in viewing.

A more interesting display of the results of the trapezoidal video pulse is obtained by time-realigning these results since the individual gates are separated by the same fundamental step size of 6.25 ns. The individual IAW1-16 Functional Units values are plotted versus a plot index I_p with each

Figure 5.17. Response of IAW1, IAW2, and IAW3 to Trapezoidal Pulse, Engineering Model Altimeter, Data of 11/13/75. Results separated vertically, plotted on Common Horizontal Axis. Horizontal Plot Index $J_p = [DDG_8 - 3334122_8]_{10}$.



individual result displaced vertically in Figures 5.18 and 5.19, and the plot index is defined by

$$I_p = [DDG_8 - 3334121_8]_{10} - N_g$$

where N_g is the (decimal) S&H gate number, 1...16, and the subscripts 8 and 10 indicate octal or decimal numbers (since the TAMS DDG thumbwheel switch setting DDG_8 is an octal number). A change of one unit in I_p is a change of 6.25 ns; the above recipe for I_p contains an arbitrary constant time-shift such that the peak of the trapezoidal input pulse occurs in S&H gate #8 at I_p=0.

The virtue of Figures 5.18 and 5.19 is that they present a concise visual indication of the quality of the calibration data and of the limitations to real satellite surface-scattered waveform recovery which exist even before consideration of the noisy fluctuating waveform and of the quantization step size of the satellite telemetry system. As already indicated, there is one DDG setting (3334140) at which two separate readings were taken and the pairs of values do not quite agree. This may be seen at the peak of IAW15, for instance, in Figure 5.19. There appears to have been a small gain drift, probably monotonic over the course of the measurement process as evidenced by the disagreement in the values obtained at each separate waveform sampler for DDG 3334140. This occurs at a different I_p for each sampler, and examination of Figures 5.18 and 5.19 immediately suggest gain drift rather than zero-drift. This may be correlated with the temperature increase over the time required for the measurements; the current test situation does not include capability for other than ambient testing and so this remains merely speculation.

Figures 5.18 and 5.19 show relatively good agreement over 14 of the 16 waveform samplers. Sampler # 4, already highly suspect because of its markedly different calibration curve, stands out in these Figures as misbehaving and there is also an evident saturation in Sampler #3. Some of the other waveform samplers show slight problems over part of their range, but these could possibly be numerical errors in averaging and transcribing the results. Overall, the conclusion from Figures 5.18 and 5.19 is that the waveform sampler set is reasonably well-behaved, and that the procedure described here

Figure 5.18. Time-Realigned Average Waveform Sampler Response to Trapezoidal Input Pulse, Sampler 1-8, Engineering Model Altimeter, Test Data of 11/13/75.

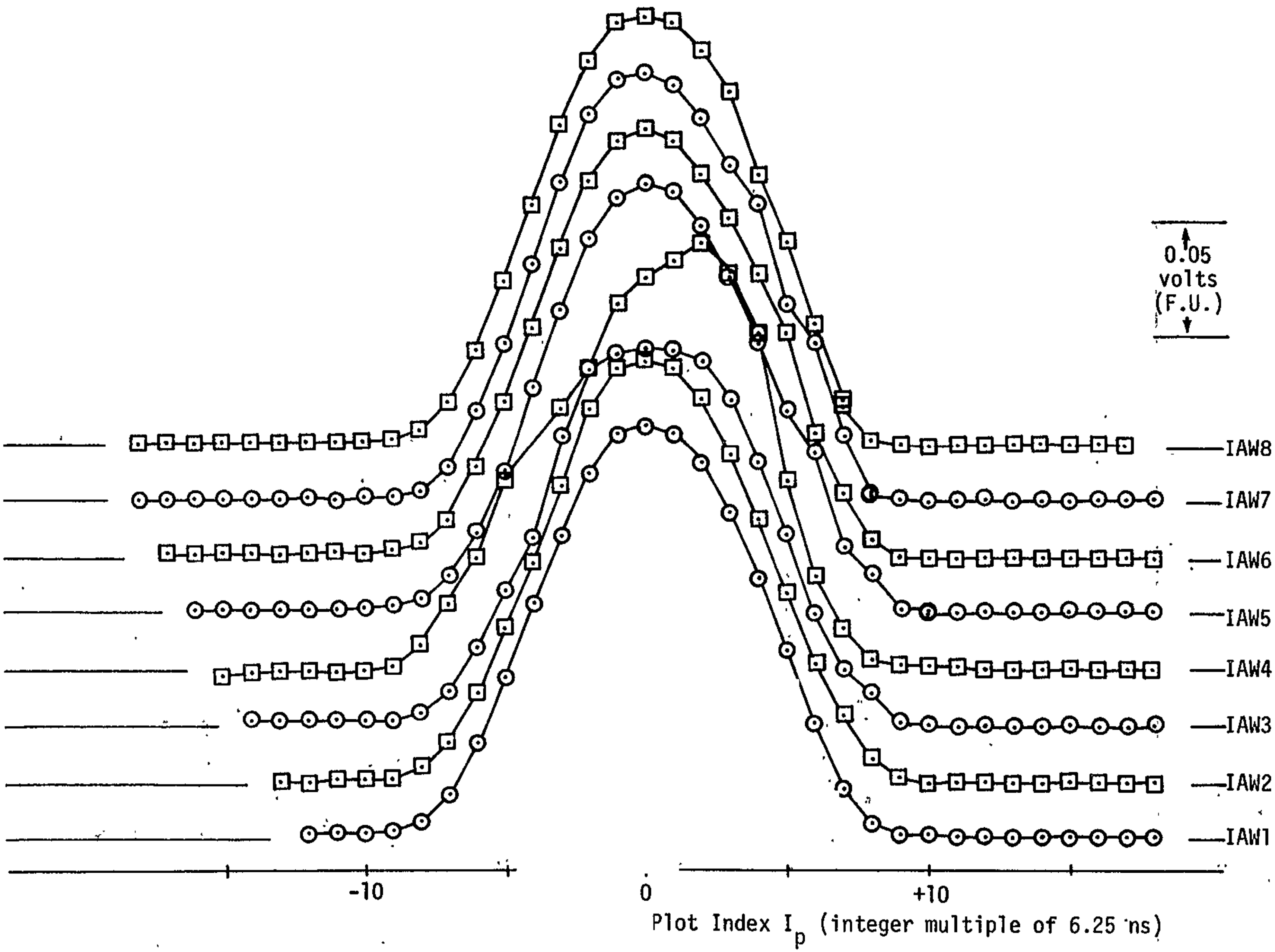
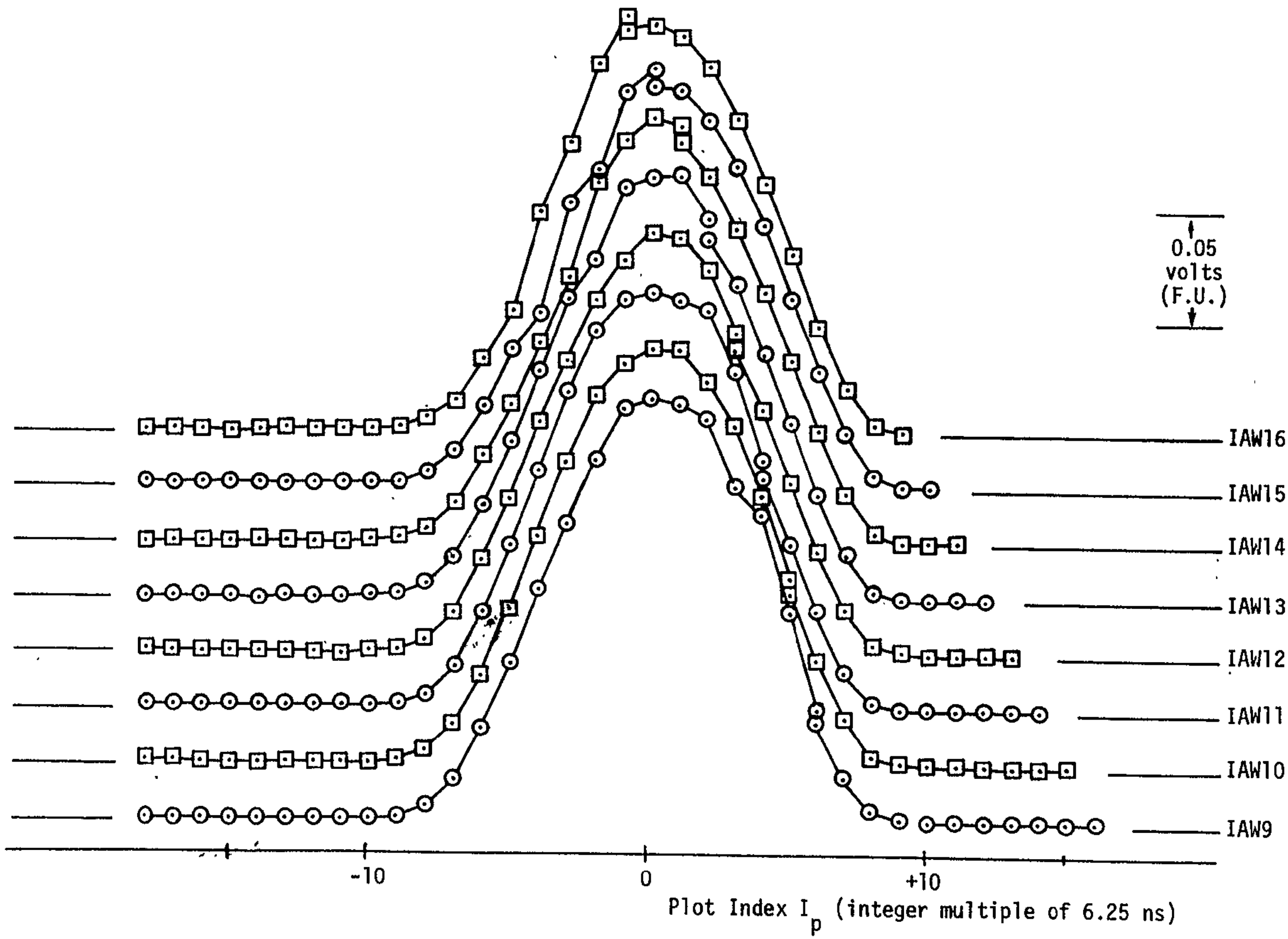


Figure 5.19. Time-Realigned Average Waveform Sampler Response to Trapezoidal Input Pulse, Samplers 9-16, Engineering Model Altimeter, Test Data of 11/13/75.



would be well worth carrying out in any Protoflight Model altimeter testing.

These results reported here were from a first trial of the trapezoidal pulse procedure and only the average waveform sampler results are presented in this report; the data for instantaneous waveform samplers simply has not yet been reduced. A fully detailed procedure is provided in this report's Appendix for a similar triangular video pulse in the proposed Protoflight Model Extended Testing. It should also be pointed out that there is clearly the need here for some alternative means of waveform sampling; the TAMS's single waveform sampler is fundamentally the same as the 16 samplers in the Protoflight Model so that something else is necessary to measure absolute shape of the test pulse before one can derive any quantitative conclusion about such phenomena as possible difference responses to ramp-up and ramp-down signals.

5.3 Independent Method of Examining Statistical Characteristics of Mean Return Waveform

In the general problem of modeling the response of the waveform sampler, an alternative or independent means of looking at the input to the waveform samplers is needed. A first step toward this is to use the TAMS alone; the TAMS Waveform Sampler contains one sampler which is representative of the set of 16 in the Protoflight Altimeter (except that the TAMS sampler has not been as carefully adjusted to zero bias). Using the TAMS Waveform Sampler plus the Saicor CAPA to determine the probability density function (PDF) at several points on the TAMS RSS noisy waveform and then using the as-yet-unspecified alternative measuring device at the same points on the waveform to obtain a second set of PDF's, the two sets of PDF's can be compared to obtain additional information on how well the TAMS Waveform Sampler correctly represents the statistical properties of the input signals.

For the alternative measurement, a sampling scope has been proposed at several times in the past but without any specific consideration of time synchronization details. The principal problem is that the CAPA to be used following a sampling scope must be synchronized to the scope's display time, <u>not</u> to the TAMS RSS pulse output time. Figure 5.20 sketches the general details of current use of the TAMS Waveform Sampler for obtaining (at the CAPA) PDF's of specified points on a RSS waveform, and Figure 5.21 shows

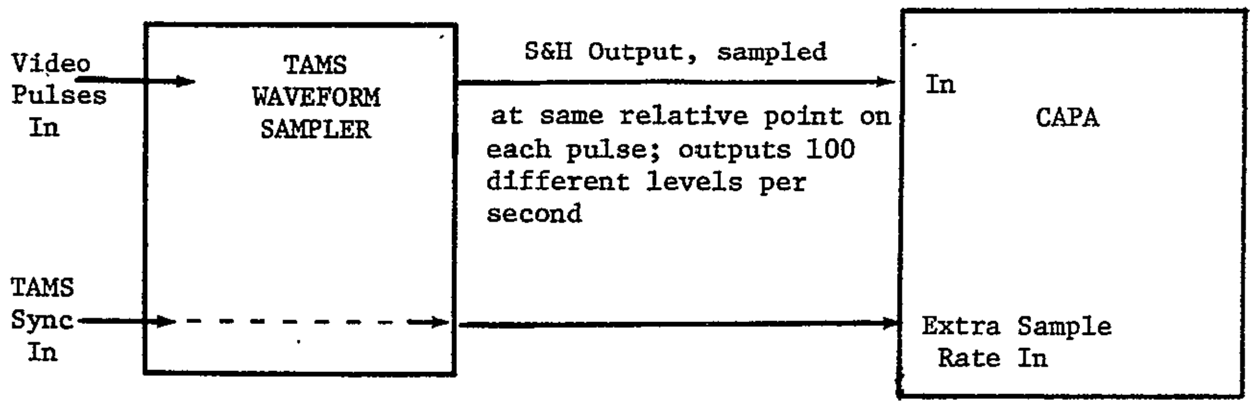


Figure 5.20. Sketch of Normal TAMS Operation Using TAMS Waveform Sampler

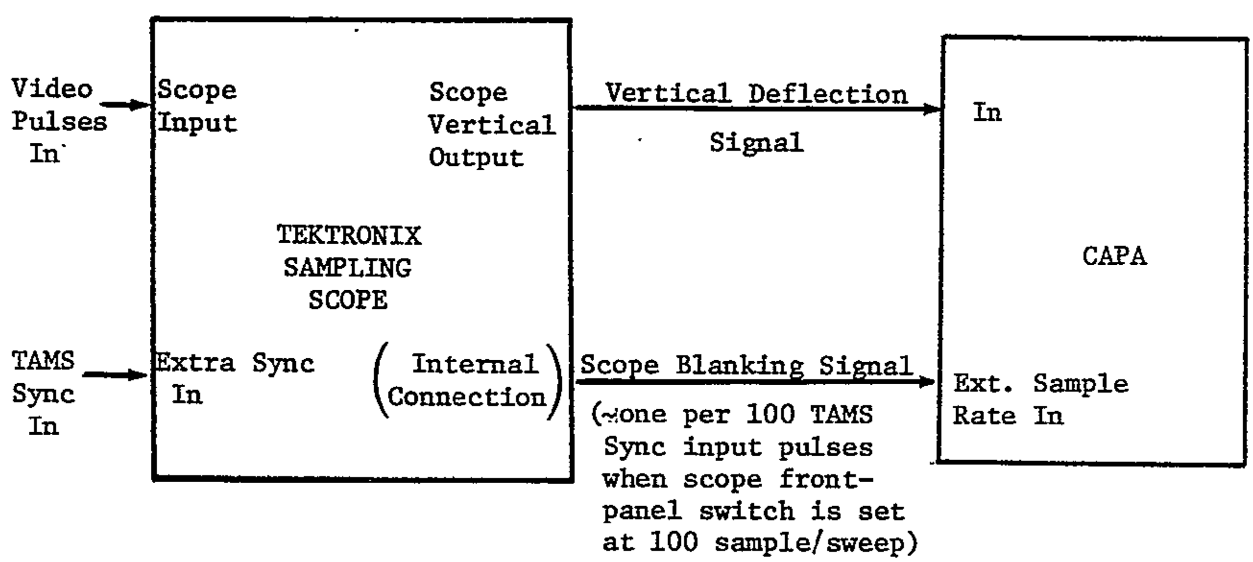


Figure 5.21. Sketch of Setup Using Sampling Scope as Alternative Waveform Sampler.

the somewhat primitive first attempt made at using a sampling scope for the alternate measurement device.

The sampling scope available for this test was a Tektronix Type 568 Readout Oscilloscope with a Type 3S1 Dual-Trace Sampling Unit and a Type 3T5 Programmable Sampling Sweep. For synchronizing the CAPA to the sampling scope display cycle the return sweep blanking signal was brought out as there was no scope front panel connector providing this. Even using the CAPA in its ENHANCE mode, the long-term mean return waveform obtained was unsatisfactory. Compared to the mean return waveform obtained from the CAPA with the TAMS Waveform Sampler, the mean waveform from the CAPA/Sampling Scope combination was noisier and "lumpier" with some type of periodic ripple (period ~ 50 - 100 nanoseconds).

In a PDF mode, the CAPA/Sampling Scope has an additional difficulty of requiring too long a time to accumulate a reasonable number of data points. This occurs because only 100 or 1000 samples per sweep are switch-selectable at this sampling scope. A 1 sample/sweep capability is needed; 100 samples/sweep means that one CAPA sample is acquired per 100+ TAMS RSS return signals, which means one CAPA sample per second (one sampler per 100 returns, and 100 returns per second). One sample per sweep, as needed here, is available on this particular sampling scope through use of external programming of the sampling sweep unit.

This report does not present any results from this first attempt at a Wavetime Sampler alternative except the characterization of this as unsatisfactory. The discussion above has centered upon timing and synchronization without any consideration of whether the effective sample aperture of the scope was adequate.

6.0 EMA TRACKING GATES TESTS

6.1 Calibration of I-Mode Averaging Gates V(N), V(A/S), V(R), and V(P)

Calibration data for these four averaging sampling gates were obtained at the same time as the data for the waveform samplers IAW1-16; both the "standard calibration" and the trapezoidal pulse measurements were carried out as discussed in Section 5 on waveform samplers.

Results of the standard calibration are presented in Table 6.1 and Figures 6.1 through 6.4. The 0.2 volt V_{in} value is obtained from extrapolation of the 0.1 and 0.15 volt values as in the waveform sampler calibration. The results look reasonable except in the case of the negative region of V(N). An operator error during the test procedure resulted in all negative-going test results having been obtained with the calibrating pulse shifted by 400 nanoseconds from its position for all positive-going pulses. Since the noise gate is the earliest of all gates treated by this process, this could be the cause of the discrepancy. If this is the problem, it is the negative part of the calibration which is incorrect. The noise gate calibration should be repeated if possible to verify this conclusion. The calibration of the other gates should not have been affected by this error.

As in the waveform sampler discussion, the response of the ramp and the plateau gates was obtained for the trapezoidal pulse (the noise and the altitude/specular gates lie outside the range through which the pulse was stepped). A different plot index J_p is defined to display V(R) and V(P) on the same time scale;

$$J_p = [DDG_8 - 3334133_8]_{10} \quad \text{for V(R)}$$

and

$$J_p = [DDG_8 - 3334145_8]_{10} \quad \text{for V(P)}$$

Figure 6.5 shows the results for this, and the agreement of the two gates is good.

Table 6.1. Calibration Results for V(N), V(A/S), V(R), V(P)

Data obtained 11/13/75 for Engineering Model Altimeter, I-Mode, by Procedure Detailed in EPTP Para. 6.3.1

Ambient Test Environment	TT1	TT2	TT3	TT4	TT5	TT6
Start-of-Procedure Temperatures	28.8°C	32.4	34.4	40.7	39.8	30.8
End-of-Procedure Temperatures	32.9	38.5	41.2	48.2	47.0	37.6°C

V_{in}, volts (Functional Units)	V_{out}, volts (Engineering Units) for Indicated Quantity			
	V(N)	V(A/S)	V(R)	V(P)
-0.20	-1.074	-3.151	-2.412	-2.370
-0.15	-0.997	-3.297	-1.597	-1.561
-0.10	-0.663	-2.223	-1.127	-1.105
-0.05	-0.328	-1.094	-0.609	-0.596
0	-0.006	-0.003	-0.105	-0.106
0.05	+1.049	+1.031	+0.389	+0.384
0.10	2.154	2.102	0.867	0.853
0.15	3.177	3.161	1.301	1.266
0.20†	4.200	4.200	1.735	1.679
0.30	4.998	4.998	2.508	2.466
0.40	4.998	4.998	3.365	3.269
0.50	4.998	4.998	3.941	3.792
0.60	4.998	4.998	3.961	3.804

†The V_{out} values for .20 volt V_{in} were obtained from linear extrapolation of the .10 and .15 volt V_{in} results instead of from direct measurement.

Figure 6.1. Engineering Model 11/13/75 Calibration Data, I-Mode, for Average Noise Gate, V(N).

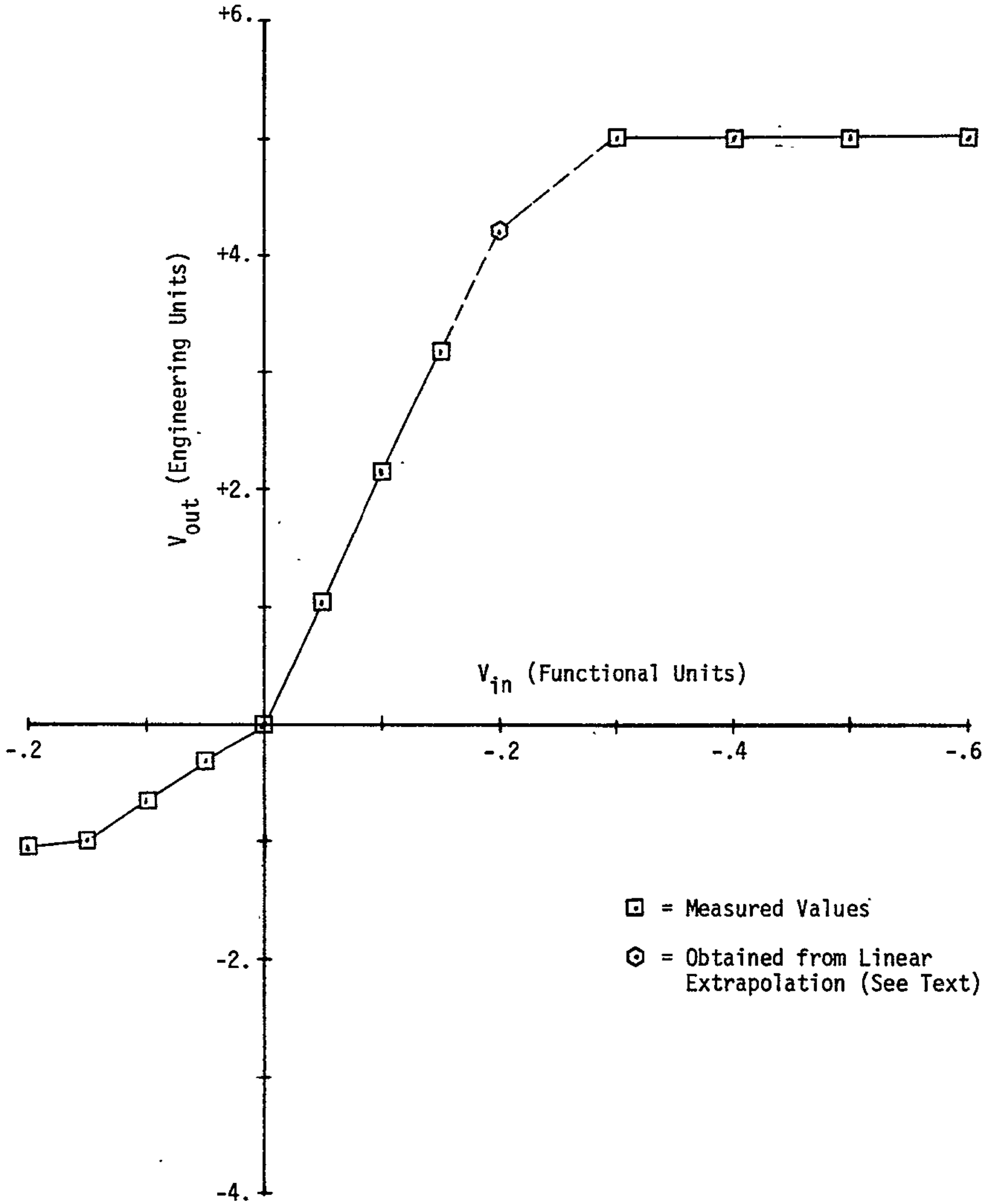


Figure 6.2. Engineering Model 11/13/75 Calibration Data, I-Mode, for Average Attitude/Specular Gate, V(A/S).

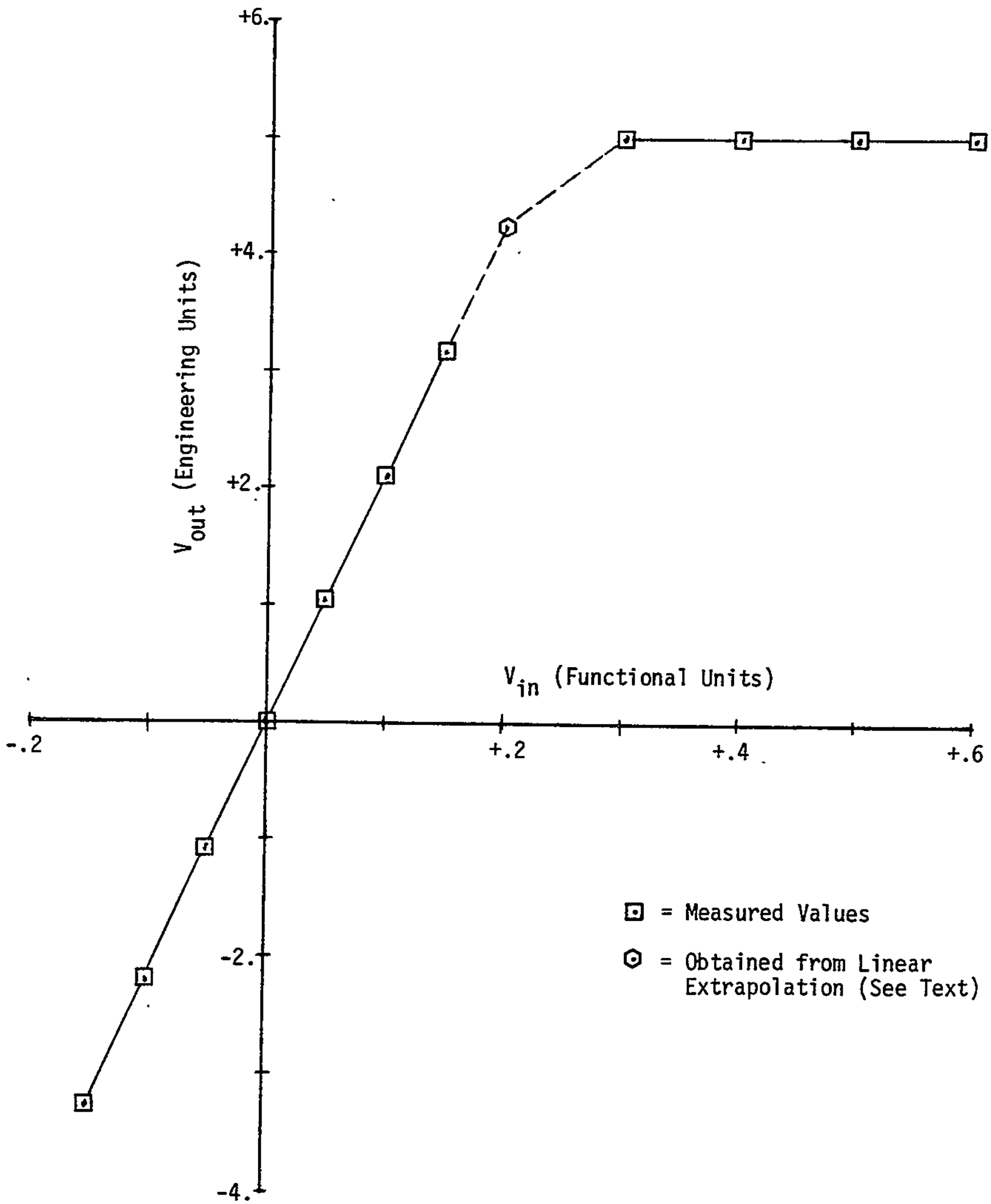


Figure 6.3. Engineering Model 11/13/75 Calibration Data, I-Mode, for Average Ramp Gate, V(R).

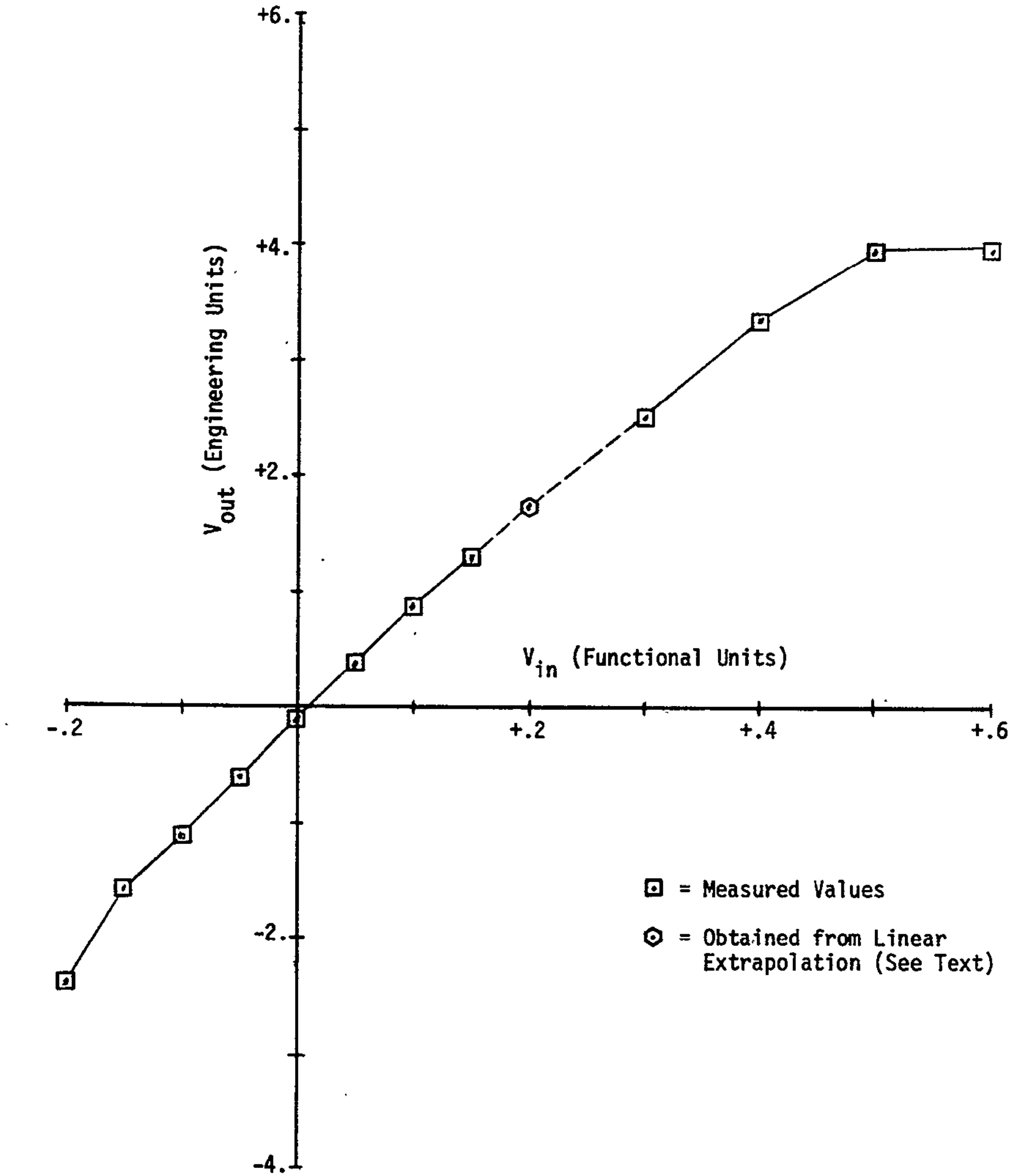


Figure 6.4. Engineering Model 11/13/75 Calibration Data, I-Mode, for Average Plateau Gate, V(P).

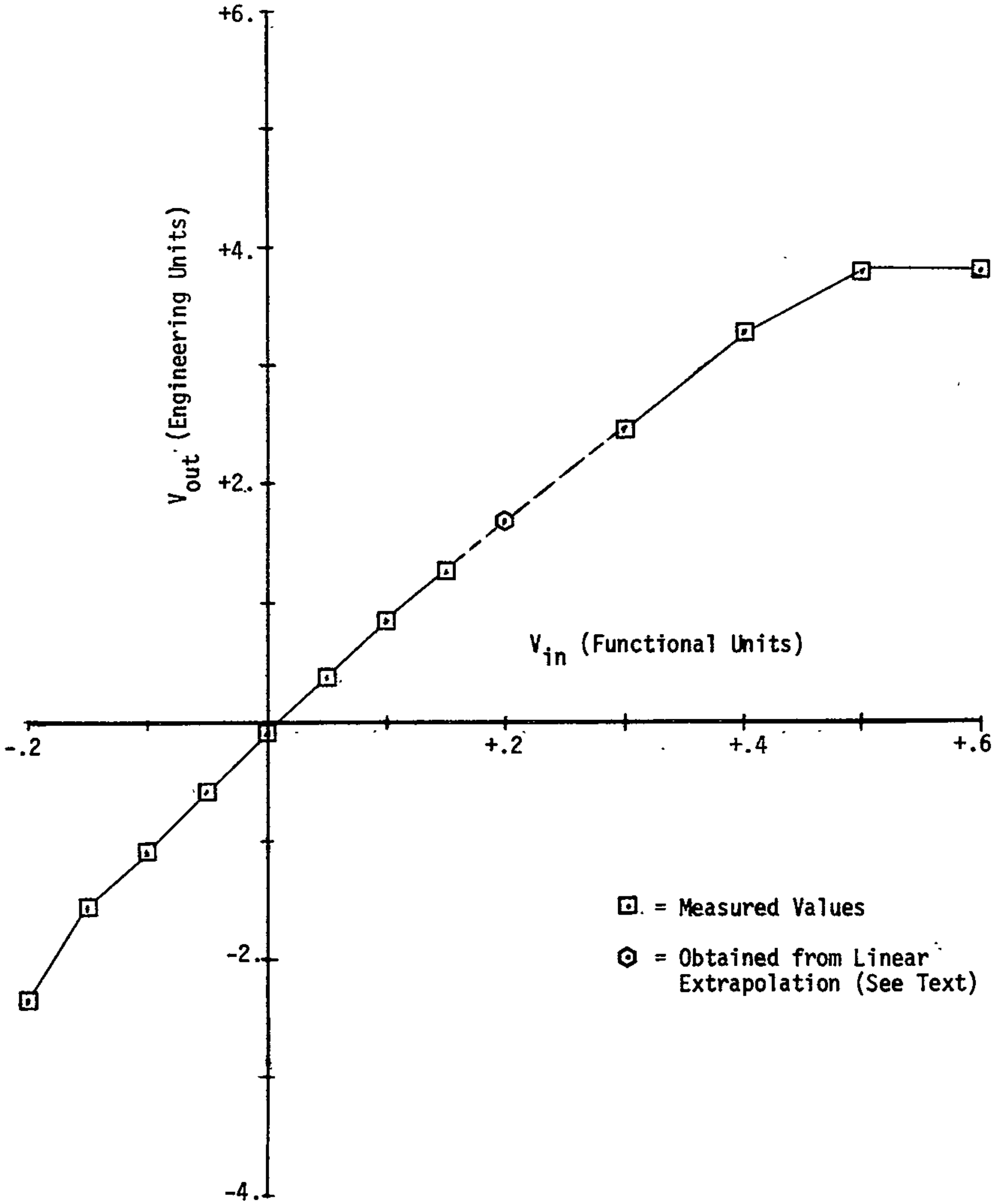
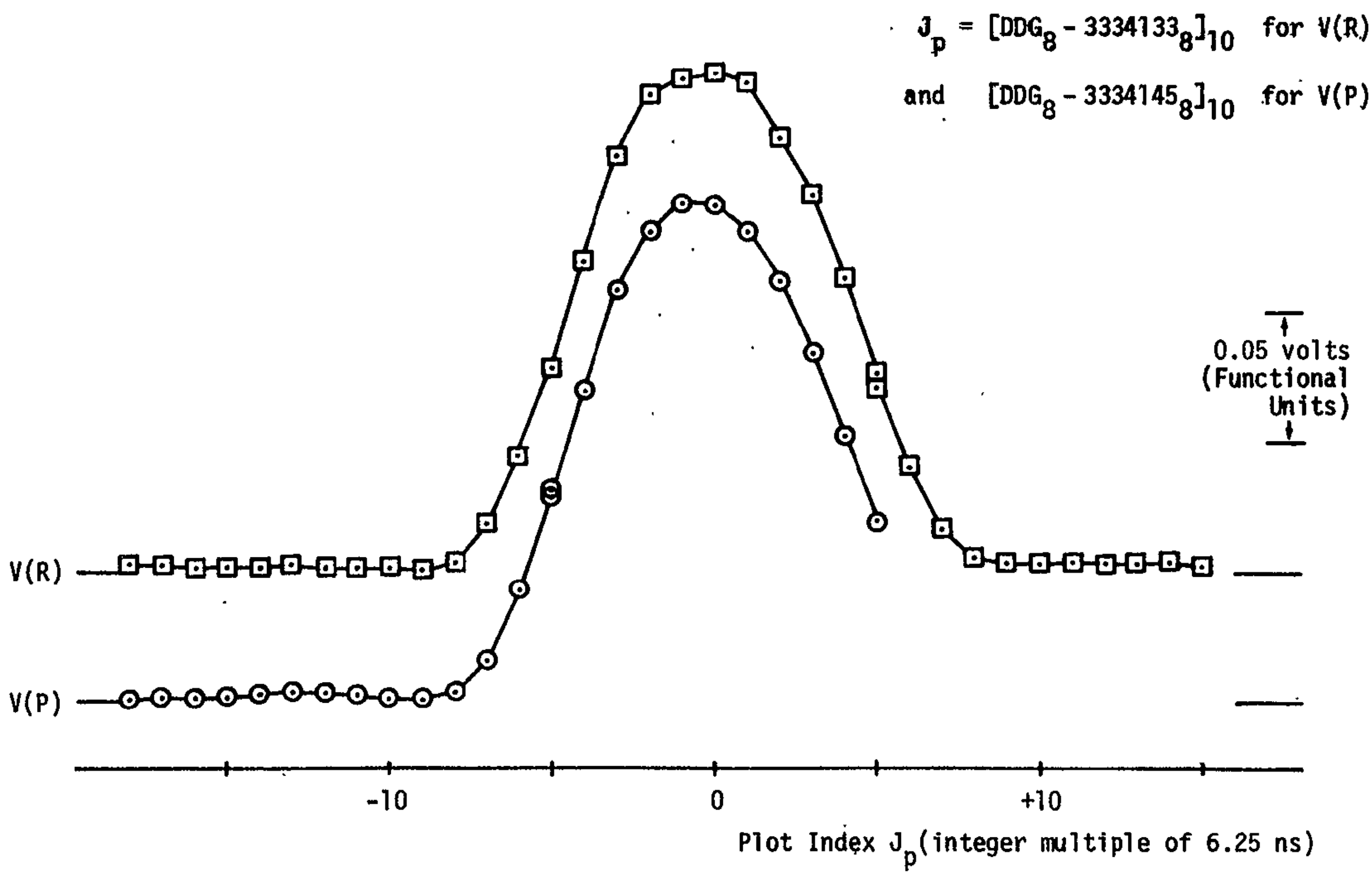


Figure 6.5. Average Ramp Gate and Average Plateau Gate, I-Mode, Response to Trapezoidal Input Pulse, Engineering Model Altimeter, Test Data of 11/13/75.



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APPENDIX

DETAILS OF TEST PROCEDURES PROPOSED FOR PROTOFLIGHT MODEL ALTIMETER.

The test procedures given here will be labelled ET0 through ET5, for Extended Tests 0 through 5. Extended Tests Class ET0 are TAMS only tests to obtain additional needed calibration data on various portions of the TAMS system. These can be carried out concurrently with the Protoflight altimeter tests, or before or after. We do not give detailed steps for tests class ET0, because there is no Protoflight Model altimeter running time to be minimized in this case. The tests in Class ET1 are functional tests to varify normal, correct operation of the Protoflight altimeter/TAMS combination; thus they are principally straight reruns of tests already specified in the EPTP. Under ET1 we list only those sections of the EPTP procedures which must be duplicated and the minor exceptions to the EPTP.

Extended Tests ET2 relate to waveform sampling calibration. ET2a is a near-repeat of the GE calibration procedure and for this we list only those changes to be made to the EPTP procedure. Test ET2b measures the waveform sampler response to a triangular hill and here an entire procedure is provided step by step. Extended Tests ET3 refer to AGC calibration, and again are similar to EPTP procedures with the important differences having to do with rf levels. Extended Tests ET4 and ET5 present an extensive list of non-standard input signals to the altimeter (non-standard in the sense of not being part of the EPTP-specified tests) to obtain further information on both the altitude tracker loop and the receiver AGC control loop; tests ET4 are for the Global Mode and ET5 for the Intensive Mode.

ET TEST PROCEDURES.

The ET procedures are listed separately on the following pages. In general the data taken will be analyzed in a manner similar to that during the recent Engineering Model tests. It is specifically required that all data items (computer printout, X-Y recorder graph, scope photos, etc.) must have at a minimum the date and time written on each. The experimenter should whenever possible provide references to specific EPTP sections, subsections or individual steps as appropriate.

While we have not written out here the data analysis steps and supplied data summary forms at a documentation level comparable to the original EPTP, we expect that the analysis will be in much the same form as that already carried out for the Engineering Model extended testing in November-December 1975.

One additional form which is supplied in this summary will provide a record of the additional time logged on the Protoflight Model altimeter during this extended testing period. Since the elapsed time meter on the altimeter primary power supply in the TAMS cannot distinguish between different altimeter states (i.e., I-Operate, G-Operate, I-Standby, G-Standby, etc.), the operator is asked to record time-of-day, and altimeter power elapsed time each time the altimeter is changed from one to another of three major states I-Mode, G-Mode, and OFF: within the two states I-Mode and G-Mode, the operator is further required to estimate the ratio of operate to total (i.e., operate + standby) time.

Extended Test ET1a,b,---,k - Protoflight Model Altimeter Functional Tests.

Purpose: The test ET1 are primarily a repeat of a subset of the GE Functional tests, to verify correct operation of the TAMS/Protoflight Model Altimeter combination and to provide data for comparison with earlier tests at GE. In several cases a test is rerun with a different setting of the RF/IF/STATISTICS ATTENUATOR than specified in the EPTP.

Procedure: Run, as specified in the EPTP, the following FUNCTIONAL TESTS, making the indicated changes if any.

Extended Test Designation	EPTP Functional Test Name	Exceptions to EPTP Procedure	Functional Test General Description
ET1a	FT2a	None	GM Operate
ET1b	FT2a	RF/IR/STATISTICS-27dB	" "
ET1c	FT3a	None	GM Calibrate
ET1d	FT6a	None	IM Track 8
ET1e	FT6a	RF/IF/STATISTICS=27dB	" "
ET1f	FT7a	None	IM Track 16 (ASSP2)
ET1g	FT7a	RF/IF/STATISTICS=27dB	" " "
ET1h	FT7f	None	IM Track 16 (ASSP3)
ET1i	FT7f	RF/IF/STATISTICS=27dB	" " "
ET1j	FT8a	None	IM Calibrate (ASSP2)
ET1k	FT8f	None	IM Calibrate (ASSP3)

Extended Test ET2a - Altimeter Static Waveform Calibration

Purpose: Measure input-output characteristics of sampling and video amplifier circuits in the altimeter. These results are for comparison with earlier measurements at GE and also will provide intermediate data points. The calibration curves generated in these tests will be used in analysis of waveform data from other extended testing.

EPTP reference: Section 6.3.1, Waveform Sampler Amplitude Calibration (SCDTI), specifically, EPTP pages 6.3-2 through 6.3-5, paragraphs 6.3.1 through 6.3.4.

Exceptions to EPTP Procedure: A modified set of input voltages is provided; specifically the range -0.20 V, to +0.40 V., in steps of 0.05 V. Also the DDG delay for non-zero voltages will be set at 3334040, to position the waveform samplers 400 nanoseconds later on the video square-wave than was provided by the EPTP-specified DDG setting at 3334140.

Procedure: The EPTP procedure is to be followed exactly; after making the following changes:

1. At the top of EPTP page 6.3-3A, change the DDG setting to 3334040.
2. Immediately preceding 6.3.3.1 (a) on EPTP pg. 6.3-3A, insert the sentences: "Record date, time, test reference, and operator(s) at the head of the computer printout. Be sure that the lineprinter has an adequate paper supply."
3. On EPTP pg. 6.3-4, change step (f) to +0.40 ± 0.004 volts instead of the +0.6 ± 0.004 volts now in step (f).
4. On EPTP pg. 6.3-4, add the following sentences both to step (m) and step (o): "Set again to CONT., repeat until four additional sets of 32 channels are obtained. On the lineprinter output next to each of the five 32 channel sets, write the ASSP position (2 or 3) and the voltage input (as set in step f)."

5. On EPTP pg. 6.3-5, replace step (p) by the instruction: "Do not tear off lineprinter results; leave in continuous strip until data analysis is performed after the test is completed."
6. On EPTP pg. 6.3-5, replace the set of voltages specified in 6.3.1.2 by: "+0.35, +0.30, +0.25, +0.20, +0.15, +0.10, and +0.05 V."
7. On EPTP pg. 6.3-5, change the DDG setting in 6.3.1.4 (a) to 3334040.
8. On EPTP pg. 6.3-5, replace the set of voltages specified in 6.3.1.4 (c) by: "-0.05, -0.10, -0.15, and -0.20 V."
9. On EPTP pg. 6.3-5, following 6.3.1.4 (c), add: "6.3.1.4 (d) Record date, time, test reference, and operator(s) on the computer printout, and remove from the lineprinter. Enter octal command 14, execute, and verify that the altimeter goes into the Intensive Mode Standby as indicated by the status word 010 111 00.

Extended Test ET2b - Protoflight Model Altimeter Waveform Sampler Response to Triangular Ramp.

Purpose: Examine response of video and altimeter's sampling circuitry to linearly changing amplitude of positive and negative slope, and to closely examine sampler-to-sampler variations in this response.

EPTP Reference: Section 6.3.1, Waveform Sampler Amplitude Calibration (SCDTI).

Relationship to EPTP Procedures: Basically, this test uses a set up procedure similar to EPTP 6.3.1 to establish a triangular ramp into the waveform samplers, and then sweeps this triangular pulse through the set of 16 samplers by incrementing the DDG DELAY switches. The specific procedure given below uses a number of steps taken directly from the EPTP 6.3.1, with additional or replacement steps added.

ET2b Procedure:

TYPE CLEAN

DESCRIPTION: VIDEO

Set up the TAMS EH139 PULSE GENERATOR (A8) OUTPUT PULSE as follows:

EH PULSE GENERATOR DELAY: MINIMUM

PULSE POLARITY to (-) NORMAL

RECTANGULAR PULSE (NEGATIVE GOING)

PULSE WIDTH: 500 NANOSEC (± 50 %)

AMPLITUDE: -0.30 ± 0.02 VOLTS (INITIAL)

TEST SET UP

Connect the output of the EH139 PULSE GEN (A8) to the VIDEO INPUT at the TEST ACCESS PANEL (A6).with W67.

At the TEST ACCESS PANEL (A6) connect the EXTERNAL AGC-V to AGC IN.

Refer to 6.2.1.9 TAMS SET UP CHARTS TEST NUMBER F17a for additional test set up requirements.

Connect the TAMS DIGITAL MULTIMETER (A10) to ANALOG MONITOR A20 test points 20 and set the TEST SELECT LINES AND RETURN switches to position 1.

Connect W58 from A22 VIDEO to J2 on the TAMS DDG (A7).

Verify that the input COMMAND status indicators at the CONTROL PANEL (A4) indicate the IM OPERATE 16 status.

24	22		21		19
0	1	1	1	1	0

Apply ALTIMETER PRIMARY POWER (ON).

At the TAMS CONTROL PANEL (A4) depress the EXECUTE button.

After approx. 3 min. verify that the voltage on the MULTIMETER A20 is greater than +2.0 volts.

Connect the VIDEO OUTPUT on TEST ACCESS PANEL (A6) to the VERTICAL INPUT OF THE TEK SCOPE.

Connect ETCC on the TEST ACCESS PANEL (A6) to the SYNC input of the TEK. SCOPE.

Observe the pulse compressed TX signal on the TEK SCOPE (Approx. 16 MICRO-SEC from the ETCC sync signal) and adjust the amplitude to 0.2 $\pm$ 0.02 VPP with the EXT. AGC ADJUST control on TEST ACCESS PANEL (A6).

Verify that the ALTIMETER STATUS WORD indicators on the CONTROL PANEL (A4) indicate the IM TRACK sixteen (16) SAMPLES status word.

1	2	3	4	5	6	7	8
0	1	0	0	1	1	1	1

Connect the TAMS DIGITAL VOLTMETER (A10) to the SENSE MONITOR test points on TAMS CONTROL PANEL (A4).

Readjust the ALTIMETER OPERATING VOLTAGE to 14.7 $\pm$ 0.05 VOLTS, if necessary.

At the TEST ACCESS PANEL (A6) set the TRACK LOCK switch to the "FREEZE" position.

At the TAMS DDG (A7) set the DELAY thumbwheel switches to 334140.

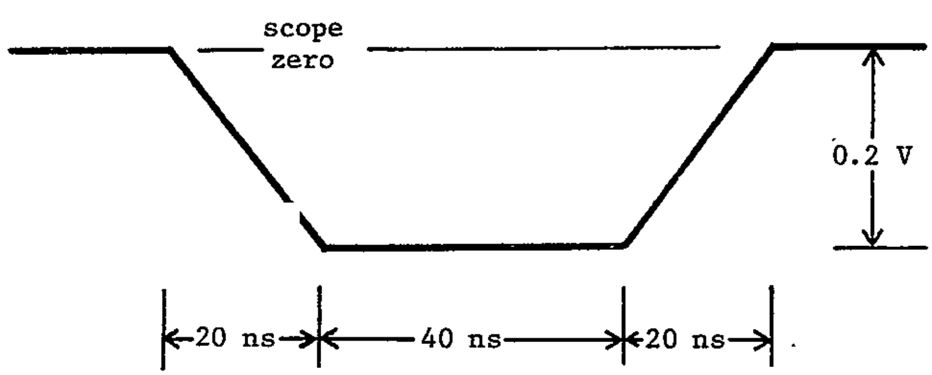
CAUTION: Do not adjust the EH139 PULSE GENERATOR (A8) DELAY setting during the performance of the remainder of this test

Load the OBJECT TAPE A/D TEST 32 CHANNEL into the TAMS COMPUTER as specified in Paragraph 7.1.

(a) Connect OUTPUT of EH139 PULSE GENERATOR (A8) to the VERT INPUT OF THE TEKTRONEX SCOPE with a vertical gain of 100 MV/DIV.

(b) Adjust EH139 PULSE GENERATOR OFFSET CONTROL to produce zero offset on the baseline.

(c) Adjust PULSE GENERATOR RISE and FALL TIMES, PULSE WIDTH and AMPLITUDE controls to produce a symmetric pulse as shown below:



(d) Photograph this signal, labelling the photograph with date, time, and test reference. Then connect COAX CABLE from EH PULSE GENERATOR OUTPUT to the VIDEO IN input at the TEST ACCESS PANEL (A6).

(e) Photograph the altimeter's video output for this pulse using the VIDEO-OUT from the TEST ACCESS PANEL (1A6), again labelling the photograph appropriately.

(f) Connect the DIGITAL VOLTMETER (A10) leads to channel 28 of the Analog Monitor with Analog Switch Selector Position 2; this reads the output of the average waveform sampler #8, GE signal IAW8.

(g) At the TAMS DDG (A7) increment the DELAY Thumbwheel switches up and down to determine the delay setting which positions the altimeter's waveform sampler #8 at the center of the peak of video input pulse. Record this DELAY setting, to be called DDG_C (C for Center).

(h) Determine the low and high DELAY settings, DDG_L and DDG_H as follows:

$$DDG_L = DDG_C - 17_8 \quad ,$$

$$\text{and} \qquad DDG_H = DDG_C + 17_8 \quad .$$

Note that all DDG DELAY settings are in octal numbers and that the octal constant 17 (as denoted by the subscript 8) is added or subtracted in finding DDG_L and DDG_H.

(i) At the CONTROL PANEL, set the COMPUTER INTERRUPT to the ON position.

(j) Record date, time, test reference, and operator(s) at the head of the computer printout. Be sure that the lineprinter has an adequate paper supply.

(k) Set the TAMS DDG (A7) DELAY thumbwheel switches to the value DDG_C.

(l) At the TAMS ANALOG MONITOR (A20) panel set the TEST SELECT LINE and RETURN switches to POS 2 (EVEN S&H OUTPUTS).

(m) At the TAMS COMPUTER set the START/CONT. switch to the CONT. position. Print out all 32 channels. Set again to CONT., repeat until four additional sets of 32 channels are obtained. On the lineprinter output next to each of the five 32 channel sets, write the ASSP position (2 or 3) and the DDG (A7) DELAY thumbwheel switch setting. Do not tear off lineprinter results; leave in continuous strip until data analysis is performed after test is completed.

(n) At the TAMS ANALOG MONITOR (A20) panel, set the TEST SELECT LINE and RETURN switches to POSITION 3 (ODD S&H OUTPUTS).

(o) Repeat step (m) above; that is, obtain and identify five sets of 32 channel values.

(p) Set the TAMS DDG (A7) DELAY thumbwheel switches to the value DDG_L, and repeat steps (l) through (o) above.

(q) Increase the setting of the TAMS DDG (A7) DELAY thumbwheel switches in increments of ONE until the setting DDG_H is achieved. For each increment, repeat steps (l) through (o).

(r) Record date, time, test reference, and operator (s) on the computer printout, and remove from the lineprinter. Enter octal command 14, execute, and verify that the altimeter goes into the Intensive Mode Standby as indicated by the status word 010 111 00.

Extended Tests ET3a,b,---,e - Protoflight Model Altimeter AGC Calibration

Purpose: AGC Calibration data to be obtained for comparison with earlier similar data taken at GE, to provide corrected curves for use with extended tests ET4 and ET5, and to acquire additional information related to the clean vs. clutter calibration problem.

EPTP Reference: Section 6.3.2, AGC Calibration Curve Tests SCDT2a through SCDT2e.

Exceptions to EPTP Procedure Referenced: Extended test ET3a corresponds to EPTP Test SCDT2a, except that a different, higher setting is specified for the RF/IF/Statistics attenuator of the RSS; this new setting is chosen to avoid saturation in the TAMS IF-to-RF upconverter. A slightly altered set of RF steps is proposed. Similarly, Extended Test ET3c corresponds to EPTP Test SCDT2c, ET3d to SCDT2d, and ET3c to SCDT2e. Test ET3b is one for which there is no direct EPTP counterpart as ET3b uses a group B, rf noisy, rectangular pulse for which there is no standard specified TAMS RSS setup.

General: The detailed procedure, given immediately below for ET3a, is derived primarily from the referenced EPTP section; ET3b through ET3e will be given in a briefer form since they will reference specific steps in ET3a.

I. ET3a Detailed Procedure:

(a) Re-establish the ALTIMETER-TAMS GM RF interface as per EPTP PARAGRAPH 8.3.

(b) Refer to EPTP 6.2.1.9 TAMS SET-UP CHARTS, TEST NUMBER FT2a for test set-up requirements.

(c) The test signal to be set up is a GROUP B, RF CLEAN, TRIANGULAR SHAPE, of VARIABLE power level. This is set up as specified in EPTP paragraph 9.2.1 except that the RF/IF/STATISTICS ATTENUATOR shall be set at 27 dB. Measure the quantity RFCPPL by the procedure given in EPTP para. 9.2.1.4.

(d) Record the RFCPPL value from (c) on the ET3 data sheet together with other appropriate test identification information.

(e) NOTE: It is intended that RFCPPL be in the range -26 dBm $\leq$ RFCPPL ≤ -25 dBm. If this is not the case, adjust the RF/IF/STATISTICS ATTENUATOR so that this criterion is satisfied and enter the RFCPPL and RF/IF/STATISTICS settings on the data sheet instead of the RFCPPl of step (d).

(f) Connect the TAMS DIGITAL MULTIMETER (A10) leads to the SENSE MONITOR test points at the TAMS CONTROL PANEL (A4).

Verify that the COMMAND status indicators at the CONTROL PANEL (A4) indicate the GM OPERATE status:

24	22	21	19
1 1 1		1	0 0

*Set the ALTIMETER PRIMARY POWER switch to ON.

At the TAMS CONTROL PANEL (A4), depress the EXECUTE button.

*After approximately three (3) minutes verify that the ALTIMETER STATUS WORD indicators on the CONTROL PANEL (A4) indidate the GM TRACK status:

1	2	3	4	5	6	7	8
1	1	0	0	1	1	0	0

*NOTE: If the ALTIMETER is in the GM STBY MODE as a result of performing paragraph 9.2.1 (RF INPUT SIGNAL SET UP), then the ALTIMETER PRIMARY POWER switch will be ON and GM TRACK status will occur in approximately 5 seconds after the EXECUTE command is given.

Verify that the OPERATING VOLTAGE is 14.7 $\pm$ 0.05 VOLTS (use the VOLTAGE ADJ. control on the TAMS CONTROL PANEL (A4) if necessary).

(g) Load the OBJECT TAPE A/D TEST ONE CHANNEL into the TAMS COMPUTER as specified in paragraph 7.1, and set the ANALOG SWITCH

SELECTOR POSITION to 3.

(h) At the TAMS COMPUTER set the STOP/REJECT switch to the RESET position (MOMENTARY). Set the START/CONTINUE switch to the START position (MOMENTARY), then select CHANNEL ENTER "1", and then ENTER "RETURN" (TT1).

(i) On the TELETYPE select INTERVAL (SEC) ENTER "1" and then ENTER "RETURN".

(j) After printer has printed a minimum of 2 lines set the STOP/RESET switch at the COMPUTER to STOP (MOMENTARY), and advance the paper in the printer a minimum of 2 lines.

(k) Repeat steps (h) through (j) above except that in step (h), use CHANNEL ENTER 2 (TT2), repeat these steps again for CHANNEL ENTER 3 (TT3), then again for 4(TT4), then 5 (TT5), and finally repeat (h) through (j) with ENTER CHANNEL 6 (TT6) in (h).

(l) At the TAMS RSS (A19) set the RF OUTPUT LEVEL ADJ. to ODB.

(m) At the TAMS COMPUTER set the STOP/RESET switch to RESET (MOMENTARY). Set the START/CONTINUE switch to START (MOMENTARY).

(n) On the TELETYPE select CHANNEL ENTER "16" and then ENTER "RETURN". Select interval (sec) ENTER "1" and then ENTER RETURN.

(o) After printer has printed a minimum of 10 lines set the STOP/RESET switch to the STOP position (MOMENTARY).

(p) Advance the paper in the printer a minimum of 2 lines.

(q) On the print out opposite the data just recorded, record the settings of the RF/IF STATISTICS LEVEL ADJ. and the setting of the RF OUTPUT LEVEL ADJ.

(r) Decrease the RF input signal level by 3 dB by using the RF OUTPUT LEVEL ADJ. (A19).

(s) At the TAMS COMPUTER set the START/CONTINUE switch to the CONTINUE position (MOMENTARY).

(t) After the printer has printed out a minimum of 10 lines set the STOP/RESET switch to the STOP position (MOMENTARY).

(u) Advance the paper in the printer a minimum of 2 lines.

(v) Steps (q) through (u) are to be repeated until TRACKER UNLOCK occurs. TRACKER UNLOCK can be determined by monitoring the TRACK LOCK test signal on the ANALOG MONITOR PANEL (A20) CHANNEL 7, with the DIGITAL MULTIMETER. When the voltage at this test point changes from greater than 2.5 volts to less than 1.0 volt tracker unlock has occurred.

(w) INCREASE THE RF input signal level by using the RF OUTPUT LEVEL ADJ. (A19) until TRACK LOCK is achieved. (Signal at ANALOG MONITOR (A20) CHANNEL 7, changes from less than 1.0 volt to greater than 2.5 volts.) RECORD on the print out the setting of the RF OUTPUT LEVEL ADJ. (A19) when the transition occurs.

(x) Reduce the RF/IF/STATISTICS ATTENUATOR setting by 10 dB. At the TAMS RSS (A19) set the RF OUTPUT LEVEL ADJ. to 0 dB, carry out steps (m) through (u), and repeat steps (q) through (u) until the RF OUTPUT LEVEL ADJ. (A19) has reached a value of 15 dB (or until TRACK UNLOCK, whichever occurs first).

(y) Repeat steps (h) through (k) (TEMPERATURE MONITORS TT1 through TT6).

(z) Command the altimeter to the mode GM STBY. Set the SELECT thumbwheels of the COMMAND portion of the CONTROL (A4) panel to 50 and depress the PRESET button. Then depress the EXEC button on the CONTROL (A4) panel. Verify that GM STBY status is attained by the STATUS WORD panel lights indication of 110 111 00.

II. ET3b Detailed Procedure:

Repeat I. ET3a Detailed Procedure from above except that step (c) should be changed to the following:

(c) The test signal to be set up is a GROUP B, RF NOISY, RECTANGULAR SHAPE of VARIABLE power level. This is set up as specified in EPTP paragraph 9.2.3 except that the rectangular pulse from the EH PULSE GENERATOR shall be at the input to MODULATION NETWORK B2 and shall be set up as in para. 9.2.2, and the RF/IF/STATISTICS ATTENUATOR shall be set at 16 dB. Measure the quantity RFCPPL by the procedure given in para. 9.2.2.4.

III. ET3c Detailed Procedure

Repeat I. ET3a Detailed Procedure from above except that step (c) should be changed to the following:

(c) The test signal to be set up is a GROUP B, RF NOISY, TRIANGULAR SHAPE of VARIABLE POWER LEVEL. This is set up as specified in EPTP paragraph 9.2.3 except that the RF/IF/STATISTICS ATTENUATOR shall be set at 9 dB. Measure the quantity RFCPPL by the procedure given in EPTP para. 9.2.3.4.

IV. ET3d Detailed Procedure

(a) Re-establish the ALTIMETER-TAMS IM RF interface as per EPTP paragraph 8.5.

(b) Refer to EPTP 6.2.1.9 TAMS SET-UP CHARTS TEST NUMBER FT5A for test set up requirements.

(c) The test signal to be set up is a GROUP C, RF CLEAN, RECTANGULAR SHAPE of VARIABLE power level. This is set up as specified in EPTP paragraph 9.3.1 except that the RF/IF/-STATISTICS ATTENUATOR shall be set at 27 dB. Measure the quantity RFCPPL by the procedure given in EPTP para. 9.3.1.3.

(d) Repeat steps (d), (e) from I. ET3a Detailed Procedure.

(e) Repeat steps (d), (e) from I. ET3a Detailed Procedure.

(f) Connect the TAMS DIGITAL MULTIMETER (A10) leads to the SENSE MONITOR test points at the TAMS CONTROL PANEL (A4).

Verify that the COMMAND status indicators at the CONTROL PANEL (A4) indicate the IM OPERATE) status:

24		22	21		19
0	1	1	0	0	0

Set the ALTIMETER PRIMARY POWER switch to ON if not already on.

At the TAMS CONTROL PANEL (A4), depress the EXECUTE button.

Verify that the ALTIMETER STATUS WORD indicators on the CONTROL PANEL (A4) INDICATE THE IM TRACK 0 status:

1 2 3	4 5 6	7 8
0 1 0	0 1 1	0 0

Verify that the OPERATING VOLTAGE ADJ. at the CONTROL PANEL (A4) to indicate 14.7 $\pm$ 0.05 VOLTS.

(g) Repeat steps (h) through (y) from I. ET3a Detailed Procedure, and add the following step:

(z) Command the altimeter to the mode IM STBY. Set the SELECT thumbwheels of the COMMAND portion of the CONTROL (A4) panel to 14 and depress the PRESET button, then depress the EXEC button on the CONTROL (A4) panel. Verify that IM STBY status is attained by the STATUS WORD panel lights indication of 010 111 00.

V. <u>ET3e Detailed Procedure</u>

Repeat IV. <u>ET3d Detailed Procedure</u> from above except that step (c) should be changed to the following:

(c) The test signal to be set up is a GROUP C, RF NOISY, RECTANGULAR SHAPE of VARIABLE power level. This is set up as specified in EPTP paragraph 9.3.2 <u>except</u> that the RF/IF/STATISTICS ATTENUATOR shall be set at 19 dB. Measure the quantity RFCPPL by the procedure given in EPTP para. 9.3.2.3.

At the end of the series of tests ET3a through ET3e, turn the ALTIMETER PRIMARY POWER switch to OFF.

Extended Tests ET4 - Protoflight Model Altimeter Response to Different Input Signal Powers and Shapes in Global Mode.

Purpose: Tests ET4 provide data for subsequent analysis to better characterize both the altimeter's altitude tracking loop and its receiver AGC control loop.

I. ET4 General Set Up:

(a) Re-establish the ALTIMETER-TAMS GM RF Interface as per EPTP para. 8.3.

(b) Refer to EPTP 6.4.1.2 TAMS SET-UP CHARTS, TEST NUMBER GM2a for test set up requirements.

(c) The test signal to be set up is a GROUP B, RF NOISY, (modified) RECTANGULAR SHAPE. This is set up initially as specified in EPTP para 9.2.3 except that the initial rectangular modulation pulse from the EH PULSE GENERATOR shall be at the input to RSS NETWORK B2 and shall be set up as in para. 9.2.2, and that the RF/IF/STATISTICS ATTENUATOR shall be set at 16 dB. Measure and record the quantity RFCPPL by the procedure given in EPTP paragraph 9.2.2.4.

ET4 Procedure for Each Test Signal and Power

During the signal set up for each different specified pulse width in, obtain a photograph of the EH PULSE GENERATOR modulation pulse observed at the TEST point on RSS NETWORK B2.

Carry out EPTP Procedure GM2a with the exception of th different input signal and level as specified in the section ET4 Test Input Signals. During the data acquisition (approx. 17 min.) and the print-out, perform the PROBABILITY DENSITY FUNCTION (PDF) and the AUTO CORRELATION FUNCTION (ACF) tests of the tracking error (H error) as specified in EPTP paragraph 7.6. The X-Y recorder procedure specified in 7.6 is adequate for the ACF results but because of the TAMS X-Y RECORDER response and the H quantization, it is necessary to manually record each

non-zero bin's contents in the CAPA, using the HP MULTIMETER and the CAPA BIN READOUT.

After the tracking error PDF and ACF are obtained, use the CAPA to obtain the PDF and ACF of the AGC Voltage, available at Channel 16 of the ANALOG MONITOR (A20). The X-Y RECORDER output is adequate for both the AGC PDF and ACF provided that the CAPA WORD POSITION is set to the lowest value for which the ACF is not "folded" across the top horizontal edge of the plot (this uses the WORD POSITION switch to partially remove the large offset present in the ACF of the non-zero-mean AGC voltage).

ET4 Test Input Signals

The general ET4 procedure specified above is to be carried out for a series of different modulation pulses from the EH PULSE GENERATOR. Common to all is the specification that the pulse is to be a normal single positive polarity pulse, that the EH PULSE DELAY setting be at its minimum value (on the lowest delay time scale), and that the EH pulse is fed into modulation network B2 and the B2 OUT is connected to the RSS PULSE 1 INPUT. The pulse shape is observed at the B2 TEST point with the oscilloscope and the baseline is set for zero offset. The pulse maximum value shall be $4.0 \pm .2$ V, and the pulse's leading and trailing edge shall both be 50 ns ramps. The pulse widths specified below are measured at the pulse's half-height points and hence ideally are 50 ns wider than the pulse width measured at the top of the symmetric trapezoidal pulse.

The series of pulse widths (at half-height) for ET4 is 200, 300, 400, 500, 600, and 1000 nanoseconds. For each of these widths, the general ET4 procedure as specified above is to be carried out for RSS RF OUTPUT LEVEL ATTENUATOR settings from 0 dB down to break-lock in 5 dB steps. Typically there will be four to six such steps. As the long procedure implied here is carried out it is recommended that the raw results be written in the TAMS EXTENDED TEST DATA summary sheet provided and that preliminary graphs be plotted for tracker jitter vs. pulse width at a single power and of tracker jitter vs. power for a

single pulse shape; this will allow any important data trends to be spotted so that additional important points can be added to the list of input pulses based on judgement of the test operators.

Extended Tests ET5 - Protoflight Model Altimeter Response to Different Input Signal Powers and Shapes in Intensive Mode

Purpose: Tests ET5 provide data for subsequent analysis to better characterize both the altimeter's attitude tracking loop and its receiver AGC control loop.

I. ET5 General Set Up:

(a) Re-establish the ALTIMETER-TAMS IM RF interface as per EPTP paragraph 8.5.

(b) Refer to EPTP 6.4.2.2 TAMS SET-UP CHARTS, TEST NUMBER IM2a and to EPTP 6.4.2.5, TEST NUMBER IM5f for the two different tests run for each signal in test ET5.

(c) The test signal to be set up is a GROUP C, RF NOISY, (modified) RECTANGULAR SHAPE. This is set up initially as specified in EPTP paragraph 9.3.2 except that the RF/IF/STATISTICS ATTENUATOR shall be set at 19 dB. Measure the quantity RFCPPL by the procedure given in EPTP para. 9.3.2.3.

ET5 Procedure for Each Test Signal and Power

During the signal set up for each different specified pulse width in, obtain a photograph of the EH PULSE GENERATOR modulation pulse by putting the PULSE GENERATOR OUTPUT directly into the scope.

With the exception of the non-standard input signals specified in ET5, carry out first EPTP Procedure IM2a, and then Procedure IM5f. (The second of these is primarily to obtain the odd-numbered set of waveform sampler results and, secondarily, to obtain per-pulse altitude tracker details in the DUMP printout.)

Parallel to IM2a, during its data acquisition and printout, use the CAPA to obtain the PROBABILITY DENSITY FUNCTION (PDF) and the AUTO CORRELATION FUNCTION (ACF) of the AGC voltage, available at channel 16 of the ANALOG MONITOR (A20). The X-Y RECORDER output is adequate for

both the PDF and the ACF provided that the CAPA WORD POSITION is set to the lowest value for which the ACF is not "folded" across the top horizontal edge of the plot (this uses the WORD POSITION switch to partially remove the large offset present in the ACF of the non-zero-mean AGC voltage). Other CAPA settings for the ACF and PDF will be similar to those in EPTP 7.6; the CAPA input attenuator, however, will have to be set according to the requirement of keeping the PDF on-scale but using most of the available ramp.

During the IM5f data acquisition and printout, use the CAPA to obtain the tracking error (H error) PDF and ACF as specified in EPTP paragraph 7.6. The X-Y RECORDER output specified in 7.6 is adequate for the ACF but because of the recorder's response and the H error quantization, it is necessary to manually record each non-zero bin's contents in the CAPA, using the HP MULTIMETER and the CAPA BIN READ-OUT.

ET5 Test Input Signals

The general ET5 procedure specified above is to be carried out for a series of different modulation pulses from the EH PULSE GENERATOR. The only difference in these modulation pulses, which are fed directly into the RSS PULSE 2 input, is that their width (as set by the EH PULSE WIDTH control) is varied in tests ET5. The EH PULSE DELAY, RISE TIME, and FALL TIME controls are all set at their minimum values on their lowest ranges. The pulse widths specified below are measured at the rectangular pulse's half-height points.

The series of pulse widths for ET5 is 40, 50, 60, 80, and 120 nano-seconds. If the altimeter will not track down to 40 ns, the minimum width at which it will track should be used. If the minimum tracking width is appreciably less than 40 ns, this should be added to the list of pulse widths to be used in ET5. For each pulse width used, the general ET5 procedure as specified above is to be carried out for RSS RF OUTPUT LEVEL ATTENUATOR settings from 0 dB down to break-lock in 3 dB steps. Typically there will be 3-4 such steps. As in the case of ET4, it is recommended that results be recorded in the TAMS EXTENDED

TEST DATA summary sheet provided and that rough graphs be made to identify possible important regions to be added to the list of input pulses according to judgement of the test operators.

______________Model Altimeter Extended Test Time Log

Altimeter Major States: 1. OFF

2. I = Intensive Mode } Operate <u>or</u>
3. G = Global Mode } Standby

Date	Time of Day	Altimeter Primary Power Elapsed Time at Major State Change	Altimeter Major State during Indicated Interval	For G or I, % of Time in Operate (Estimate)	Running Subtotal Time in Operate			Remarks
					G	I	Both	

(form Rev. 1/9/76)

Extended Tests ET3_____ - AGC Data Sheet

__________ Altimeter Model

Ambient Environment TAMS Ser. #_______ RSS # _______________

Thermistor Readings

ASSP3, MUX channel	Measured Quantity		Before Test		After Test	
			Volts	°F	Volts	°F
1	Transmitter Temp.	TT1				
2	Receiver ,	TT2				
3	G-Tracker ,	TT3				
4	I-Tracker ,	TT4				
5	Waveform Sampler,	TT5				
6	BIT/CAL ,	TT6				

Test Signal Characteristics

ALTIMETER MODE G__________ I__________

RF Clean __________

Noisy __________

PULSE SHAPE: Rectangular______

Triangular______

Other ______

ET-Specified RF/IF/STATISTICS LEVEL ADJ.= ______dB

Measured RFCPPL(for this RF/IF/STAT) = ______dBm

RF/IF/STAT 9dB less attenuation than above=______dB

Measured RFCPPL(for this RF/IF/STAT.) =______dBm

PULSE NETWORK: B1 _____ B3 _____ B2 _____ None_____

NOISE/SINEWAVE PULSE ADJ________dB

NOISE MOD ADJ ______________dB

Measured IFCPPL = ______________dBm

CCV + WGL = ______________dB

← measured →					← derived →		
RF/IF/STAT. LEVEL ADJ. (dB)	RF OUTPUT LEVEL ADJ. (dB)	Receiver AGC(Volts), ASSP3, MUX 16 (Results from 10 readings)			Calculated Test input Power (dBm)	RF OUTPUT LEVEL ADJ. Calibration Value (dB, from 4.7)	Appropriate RFCPPL→ CCV + WGL (dBm)
		MIN	MAX	MEAN			
		UNLOCK		VALUES			
		RELOCK		VALUES			

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